TRANSMISSOMETRY AND PARTICULATE MATTER DISTRIBUTION ON THE EASTERN GULF OF MEXICO SHELVES, MAFLA SURVEY, 1975-76

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EXECUTIVE SUMMARY

Transmissometry measurements have been performed at seasonal intervals along four transects in the Eastern Gulf of Mexico, ranging from Clearwater, Florida to Mobile Bay. In summer and early fall of 1975 most areas except the vicinity of the Mississippi Delta showed clear waters having upwards of 80% light transmission (coefficient of attenuation less than $u = 0.22$ or roughly <.2 mz/L total suspended matter) in the upper water columns . A few meters from bottom, however, more turbid layers characterized inshore waters.

In winter (January and February, 1976) shelf waters were turbid over long periods, due to repeated resuspension of fine fractions of bottom sediments owing to storms. Inshore shelf waters were vertically well mixed to a considerable degree. Transmissivities of 50-60% ($\alpha = 0.7$-0.5 or about 0.5 mg/ℓ were common during this period. These data correspond to finding that particulate detritus resembled bottom sediments mineralogically during the winter period (Huang,1976), and included appreciable carbonates at certain locations.

Turbidity distributions are frequently closely related to water mass structures and movements. A notable example was provided by phenomena observed on the Middle Ground a few days after Hurricane ELOISE (September 26, 1975). Sharply defined turbid boluses of near-bottom water were related to temperature, salinity and density anomalies interpreted as contour currents, which were enhanced by the forcing function of the violent storm.

INTRODUCTION

Suspended matter studies of analytical or optical character are limited in the Gulf of' Mexico in general and in the eastern Gulf in particular (Manheim, et al.,1972; Carder and Schlemmer, 1973, and references cited). Generally speaking the data available prior to the current MAFLA Survey suggested that the waters in the Eastern Gulf shelf regions may be highly transparent, reaching tenths of 1 mg/ℓ total suspended matter within only a few kilometers of shore. Greater turbidity has been noted on approaching the Mississippi Delta, around which sharp-edged, turbid plumes are characteristic. Storms are presumed to have significant influence on turbidity distribution, but details of their influence on the shelf regions of the eastern Gulf have been unavailable. Carder and Schlemmer (1973) concluded that the suspended particle distribution above the slope and outer shelf of the eastern Gulf was highly dependent on the Loop current and associated eddies.

The first MAFLA Survey (1974 - 75) included total suspended matter, particulate organic carbon (POC), and other particulate measurements on discrete samples in five major oil lease tracts. These data implied the existence of very low turbidity regimes over much of the W. Florida shelf, but were puzzling in that they did not adequately reflect the heavy turbidities in the Delta region, as confirmed at times by bottom photographs and divers' observations. Irregular spatial and temporal variability in turbidity was postulated to account for some discrepancies (Manheim, 1975).

In the following 1975 - 76 MAFLA Survey optical transmissometry measurements were added to the study plan in order to provide regional "background information and vertical and spatial variability of particulate concentrations. These would aid in assessing the turbidity regime and interpreting the significance of other suspended solid measurements such as total suspended particulate matter (SPM), mineralogy, particulate organic carbon, hydrocarbons, trace metals, and primary productivity.

During the first sampling season late negotiations, and subsequently late arrival and failures of equipment supplied by manufacturers resulted in only small recovery of information. In season II profiles were obtained for roughly 80% of envisaged stations. For season 111, despite problems, data were obtained for 100% of envisaged stations. The overwhelming bulk of data were obtained with a Hydro Products instrument. The method chosen for display of these data was that of sections of transmission (T %) based on depth profiles along transects were permitted by the distribution of water column and intermediate stations (Figure 1). Digital records of the data are also available (Appendix 1).

In addition to the optical information, a number of water samples were filtered through Millipore filters for the purpose of visually characterizing the types of particulate matter involved. Such data were useful in calibrating and relating the optical data to analytical measurements performed by other investigators, and to sediment transport processes on the shelf.

We wish to acknowledge the assistance of Mack Barber, Bill Jester, Harvey Mason, Tom Tyska and Ted White in maintaining the equipment in functioning order and to thank Tom Pyle, Ted White, J. E. Alexander and M. Rinkel for their special efforts and cooperations with the transmissometry

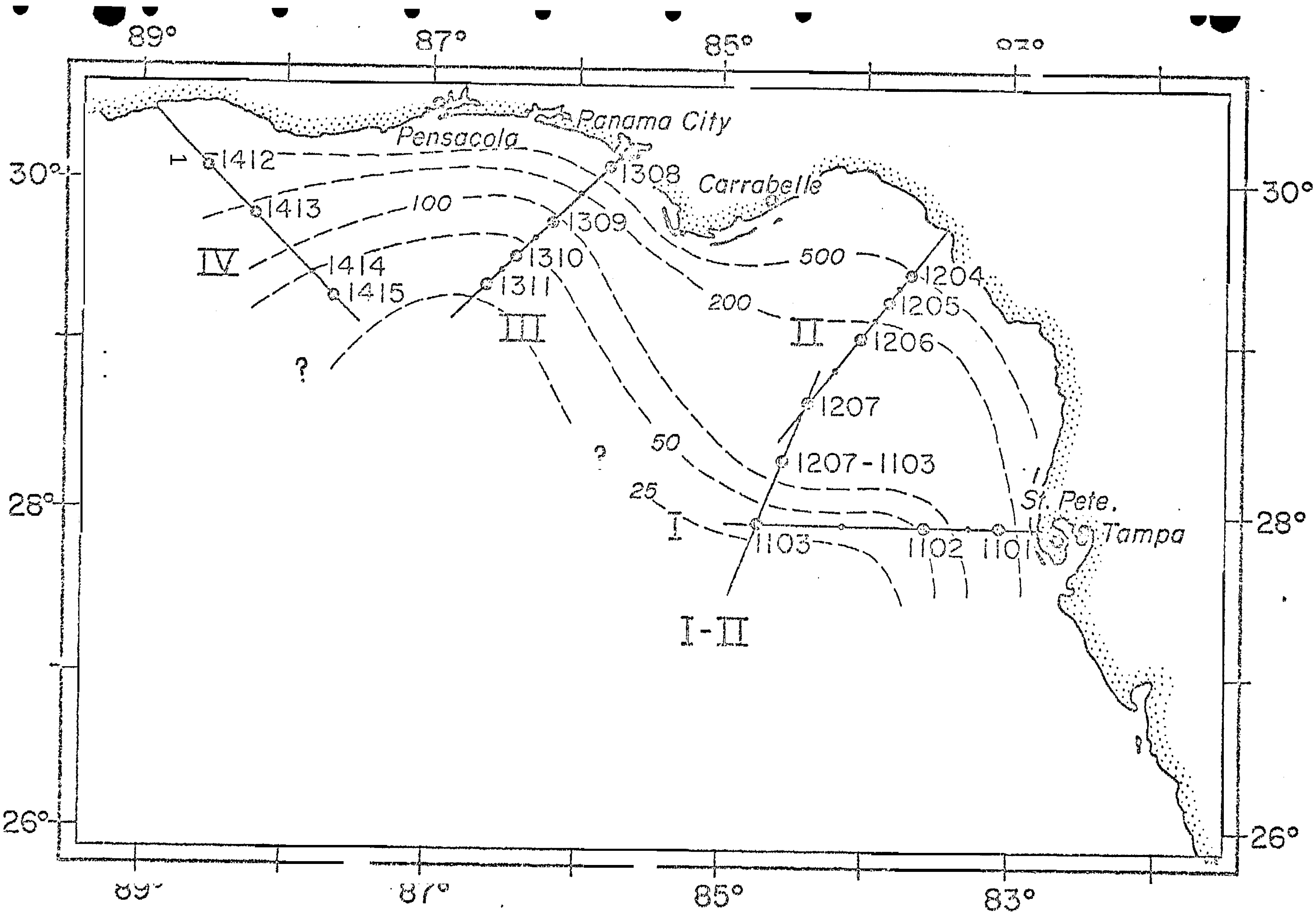
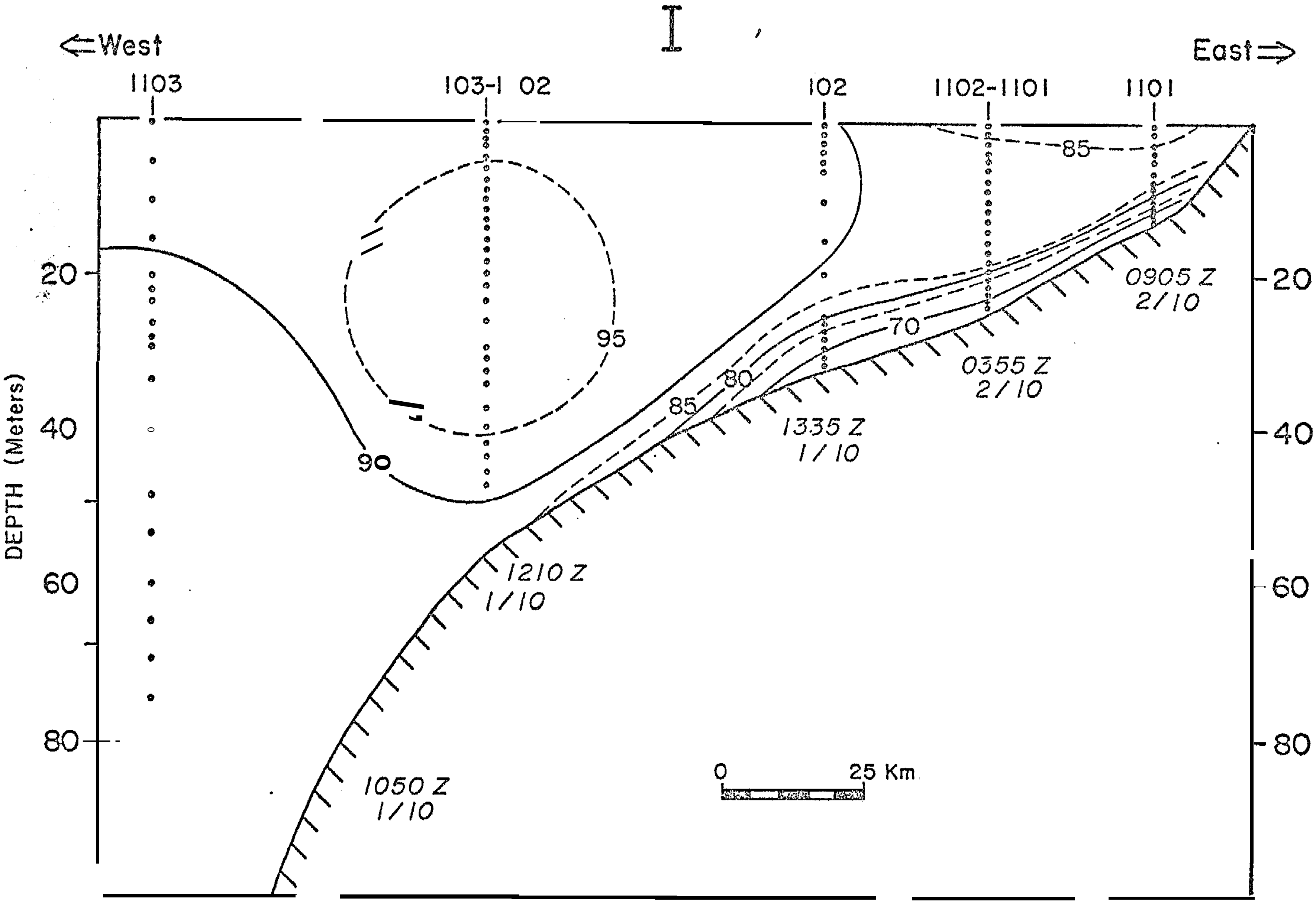


Fig. 1. Location map of water column stations and transects.

program. Our thanks go to our colleagues in the MAFLA studies for making data available at early stages, and to J. L. Simon for his equipment loans.

The above features indicate that natural dispersal and sinking of spilled hydrocarbon slicks will be greater in winter by a factor of three or more than in summer. We should also expect tract metal content of particulate matter to be enriched in constituents characteristic of carbonate and ferrigenous particulate matter.

Taking turbidity distributions and other factors into account, we suggest that the talc reported by Huang represents an indicator of land-derived matter of industrial origin. Extending interpretations of the turbidity distributions to measurements such as hydrocarbons and trace metals in particulate matter, we conclude that inshore samples (10 m below sea surface) were reasonably representative of the entire water column in winter, but not in summer. During the former period the particulate matter represents a fine, mobile fraction of local bottom sediments (surficial), whereas during the summer long-distance transport of fine (probably highly organic) particulate in the upper water column are characteristic. The features mentioned above are particularly well illustrated in Figure 4 and 9.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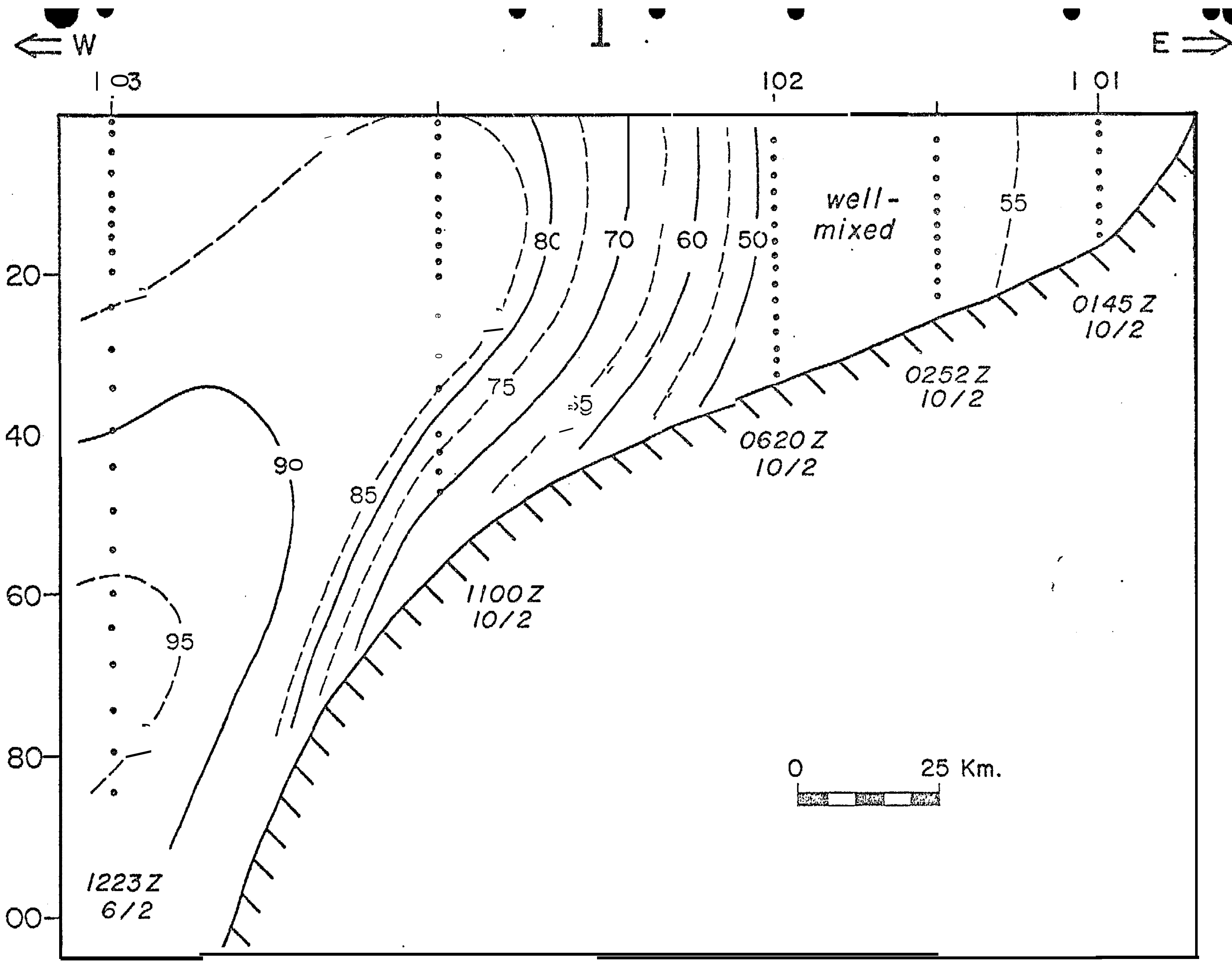

Fig. 9 Transect I Season III % Transmission

METHODS

As pointed out by Tyler, et al (1974) practical optical measurements of particulate matter have lagged behind the theoretical groundwork of Mie (1908), Hulbert (1945) and Van de Hulst (1957). However, the sensitivity and rapidity of optical measuring devices have promoted the use of transmissometers (alpha meters) and nepheiometers (scatterance meters) for measuring distribution of suspensoids in water columns. A summary of information in this area is provided in Gibbs (1974) and Jerlov (1968).

The main optical data for the present study were collected during three sampling seasons 1975 - 76 by a Hydro Products Model 912 transmissometer having a 20 mm diameter beam collimated over a one meter path length, with peak photocell response at 5500 Å (550 rim). This unit was equipped with a 350 foot (approximately 100 m) cable. Readouts were obtained on deck each one to two meters for shallow stations, and at somewhat wider intervals for deeper stations.

A few measurements were obtained with a cableless Montedoro-Whitney unit originally intended as the primary unit, but whose self-contained chart recording system proved to be poorly designed and permitted only limited use of the instrument. Examples of traces from these instruments are shown in Figures 2 and 4.

For the present purposes the operation of the transmissometers is described by the equation:

$$\frac{I}{I_o} = e^{-\alpha x}, \text{ or } \alpha = \ln \frac{I}{I_o} \text{ where } x = 1m.$$

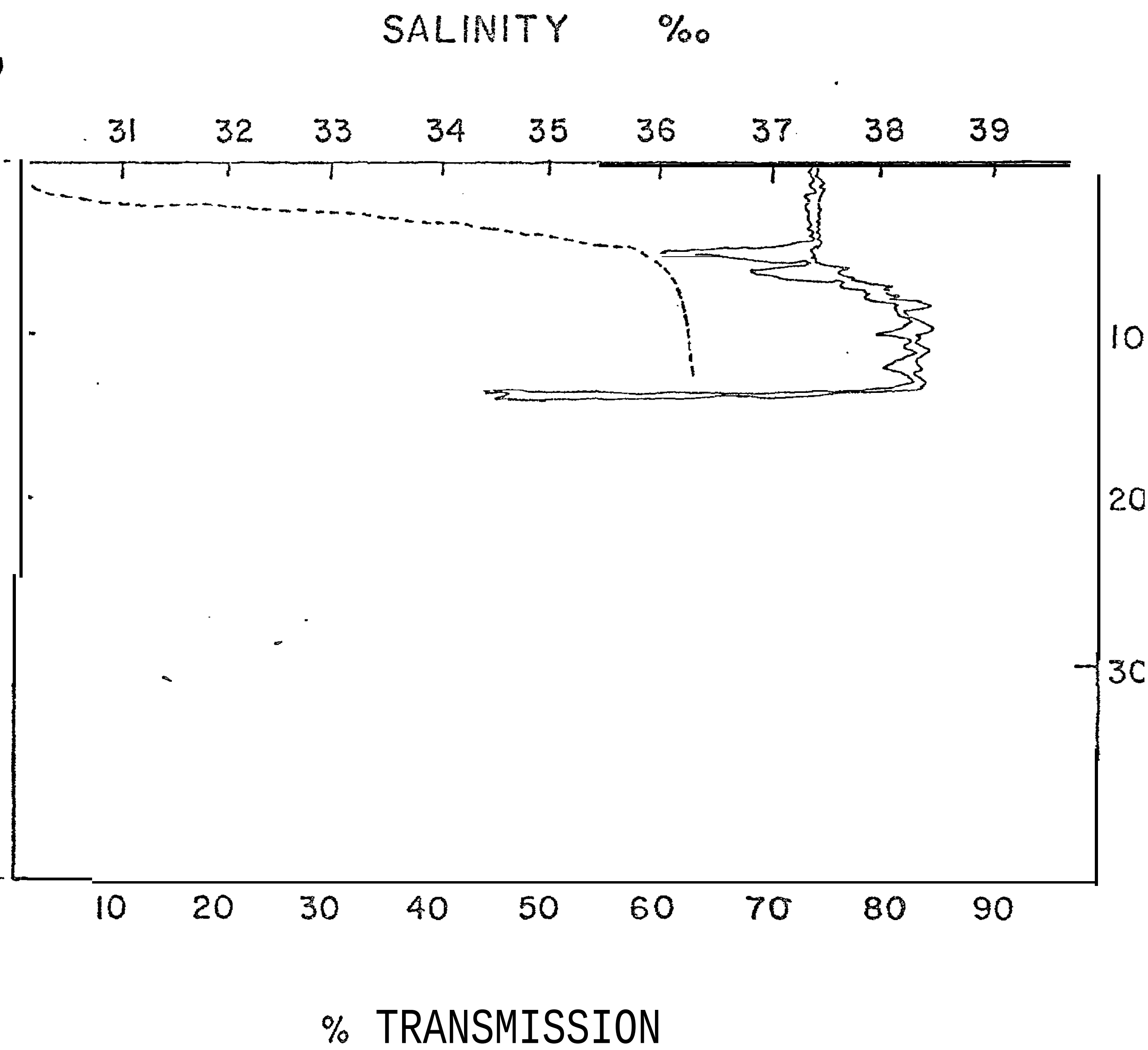

Fig. 2. Transmissometry trace for Montedoro-Whitney instrument, Sta. 1412-1413, Sept. 9, 1975. The offset in the lines represents differences in down-up traces. Extra scale refers to approximate salinity, (halocline) values at the site. Note the turbid layer at the boundary between well-mixed shelf water above, and clear Gulf water below. This turbidity is probable organic matter collected at a strong density interface (pycnocline).

The basic operational unit is % of transmission with respect to theoretically maximally transparent water (distilled water); i.e. for the reference 'solution itself, $I/I_0 = 1.00$ or T = 100%. As a practical technique, before each station lowering the transmission of the instrument is checked with neutral density filters in air. Depending on the optical design of the instrument, air transmission may be higher (Montedoro-Whitney) or lower (Hydro products) than in pure water. Raw data collected with the HP instrument were corrected on board utilizing the optical correction information, and assuming that a transmission of 92% in air corresponded to 100% transmission in pure water, according to manufacturer's data. Without special bulk filtration systems the purest distilled-deionized water available in the laboratory has a % transmission of approximately 90 - 92, whereas" offshore waters in the Gulf reached values of 95%.

Further calibration has been performed to relate T and α values to suspensoid concentrations determined by filtration and weighing techniques (Betzer, 19'76). Although some preliminary calibrations were performed with artificially suspended materials such as kaolinite*, comparison with measurements of suspended particulate from actual water under investigation provides more meaningful intercalibrations, and allows extrapolations and interpolations of analytical information over areas having similar particulate matter character. For such purposes α is the preferred optical unit , since it has been demonstrated that for a given fluid medium and type of suspended particulate matter α is proportional to particle mass (weight) per unit water volume over a wide range of concentrations. A

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* See discussion of calibration of turbidity units in McCarthy et. al., (1975).

plot of α against SPM for typical MAFLA waters is given for Leg II (September, 1975) in Figure 3.

Since all SPM data were obtained at 10 m, few of the high turbidity layers noted near bottom were sampled and particulate weights obtained. To give an indication of calibration for higher turbidity regions, data from layers in Hueneme Canyon, off Southern California (Drake, 1975) are plotted. These data are in reasonable agreement with information on terrigenous detritus from West African continental margin (Carder and Betzer, 1974). Offsets from the data of Drake reflect variable response of light attenuation to particle mass, depending on the proportion and kind of organic matter present and its degree of decomposition, the size, shape and refractive index of mineral matter and possible presence of colloidal and coloring matter (Gelbstoff) in waters. However, for the present purposes the chart provides an approximate guide to SPM magnitudes for the transmissometry distribution.

Aside from the Montedoro-Whitney instrument, chief problems occurred in matching cables to light source, systems instability owing to current leakage in cable connectors, gasket leaks in the light source housing, and other electrical system problems. When occurring, these problems were apparent and modifications were made before sampling was continued. With few exceptions, we feel that intra-trace values are reproducible to within the rounding of the data.

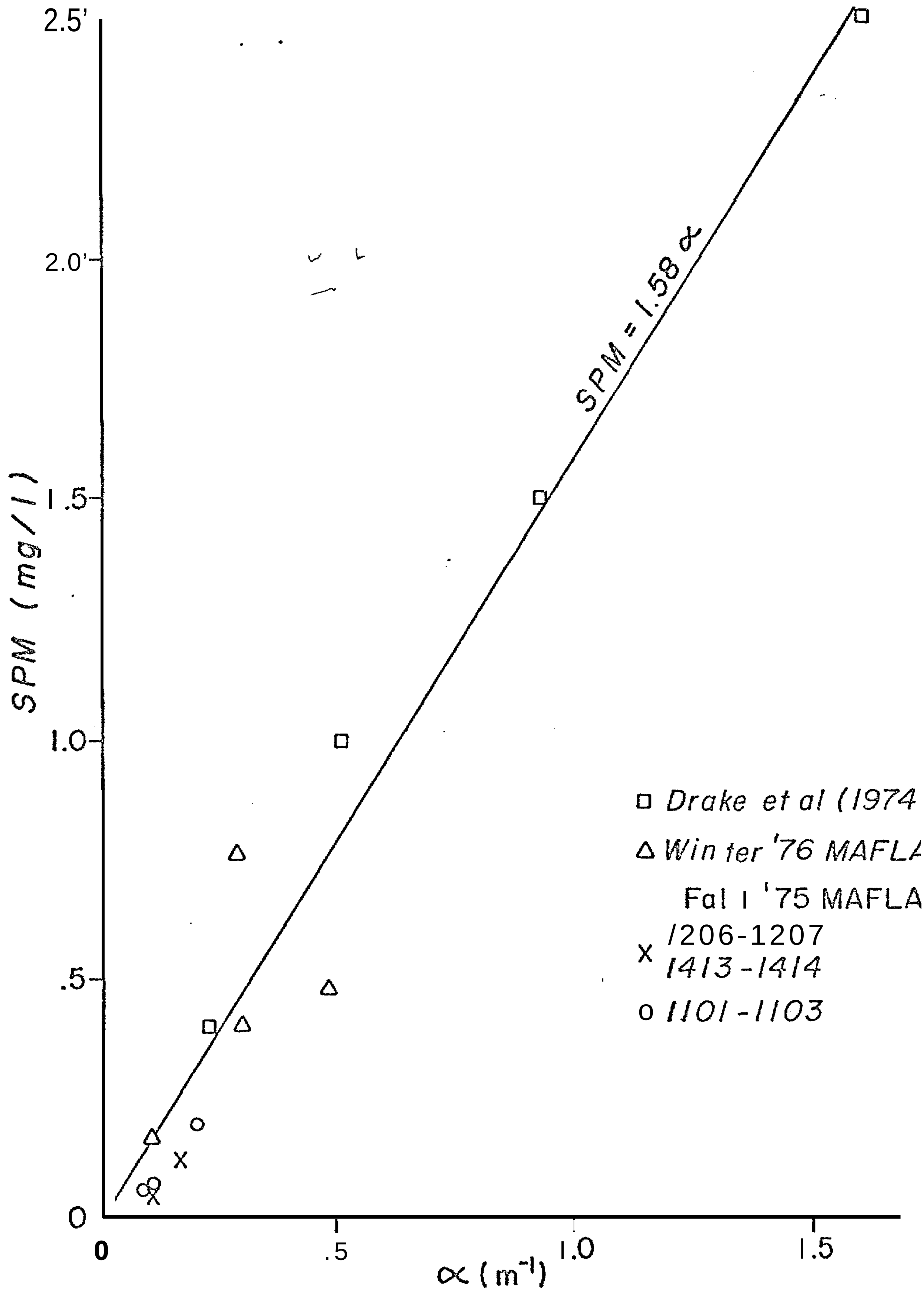


Fig. 3. Calibration of transmissometry with total suspended matter (SPM). Shown in the plot of extinction coefficient (a) against SPM are data from MAFLA and from southern California (Drake et. al., 1974).

RESULTS

Seasonal shelf transects

Available data for sampling season I (June - July, 197'5) are given in Appendix 1. Data for sampling season II (September, 1975) are presented in the form of transects in Figures 4 - 8. The chief features noted are the strong vertical stratification and development of bottom nepheloid layers as in Figure 4, the clear offshore and Loop waters again noted in Transects I and IV, and the turbid bottom layers associated with Hurricane ELOISE in Transect II (Figure 5). Near-bottom filtered samples (1.7 ℓ Niskin bottles) from the turbid layers in the Hurricane-influenced Transect II revealed dominance of fine carbonate particles, similar to bottom sediments in the general region. Unfortunately, special samples filtered from 1.7 ℓ Niskin bottles for SPM analyses showed probably far too high values (approximately 200 mg/ℓ) to be correlated with the transmissometry data.* As expected, turbidity increased markedly toward Mobile Bay (Transect IV, Figure 8).

Data for sampling season III (January - February, 1976) are given in Transects I - IV in Figures 9 - 13. The greater vertical homogeneity of particle distributions in the nearshore water column is immediately obvious. The lack of synopticity during the winter sampling emphasizes the temporal nature of turbidity regions. One or two days' difference may result in a completely altered distribution pattern.

Twenty-four hour transmissometer stations

To provide an initial estimate of the short-term temporal variability

* See later discussion.

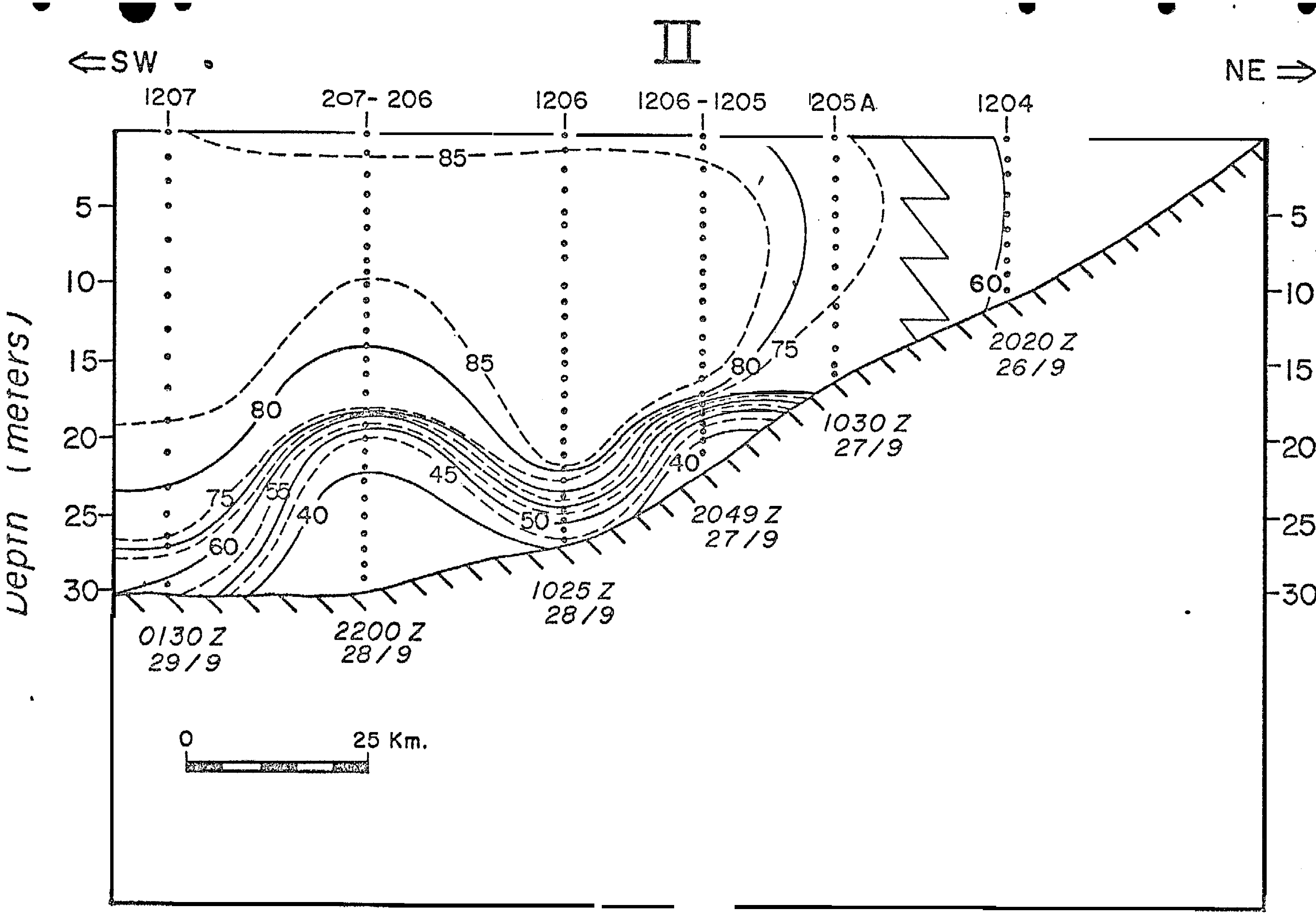


Fig. 5. Transect II., Season II. Zig-zag line denotes break in continuity; Sta. 1204 taken before Hurricane Eloise, other stations post Hurricane.

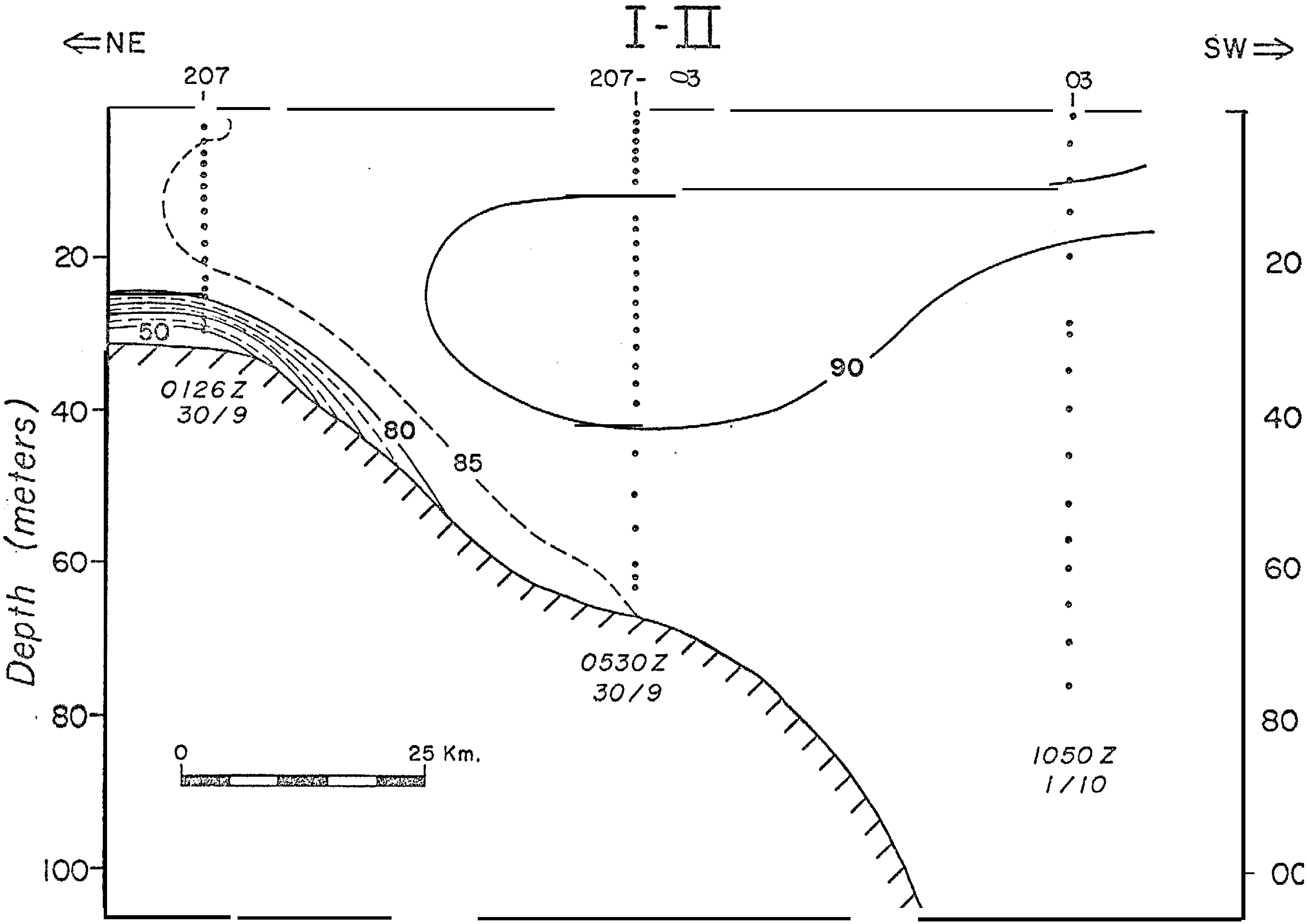
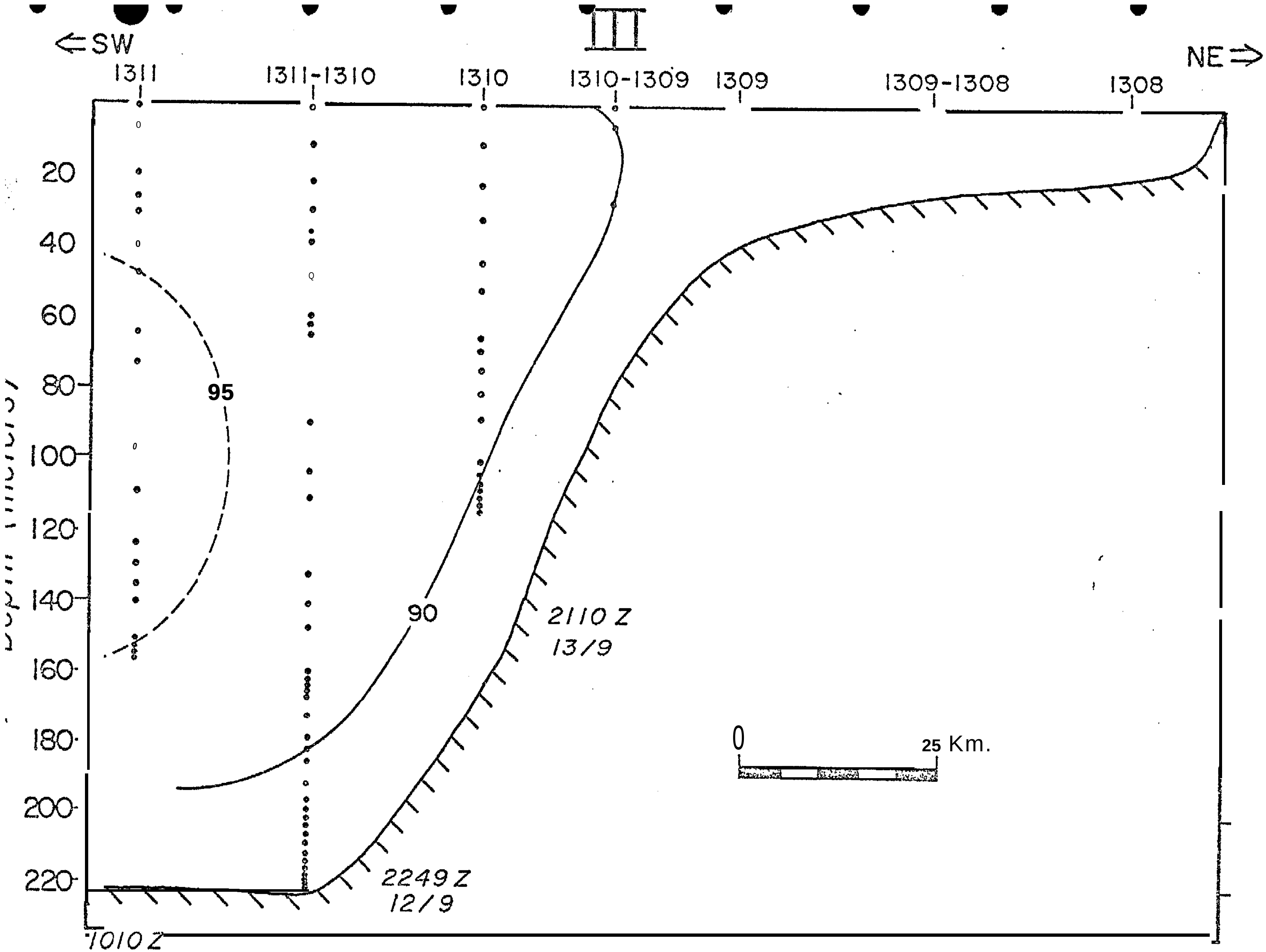


Fig. 6. Transect I-II., Season II. % Transmission



Fig, 7. Transect III. , Season II. Montedoro-Whitney traces calibrated to match Hydro-Products through SPM-α adjustment.

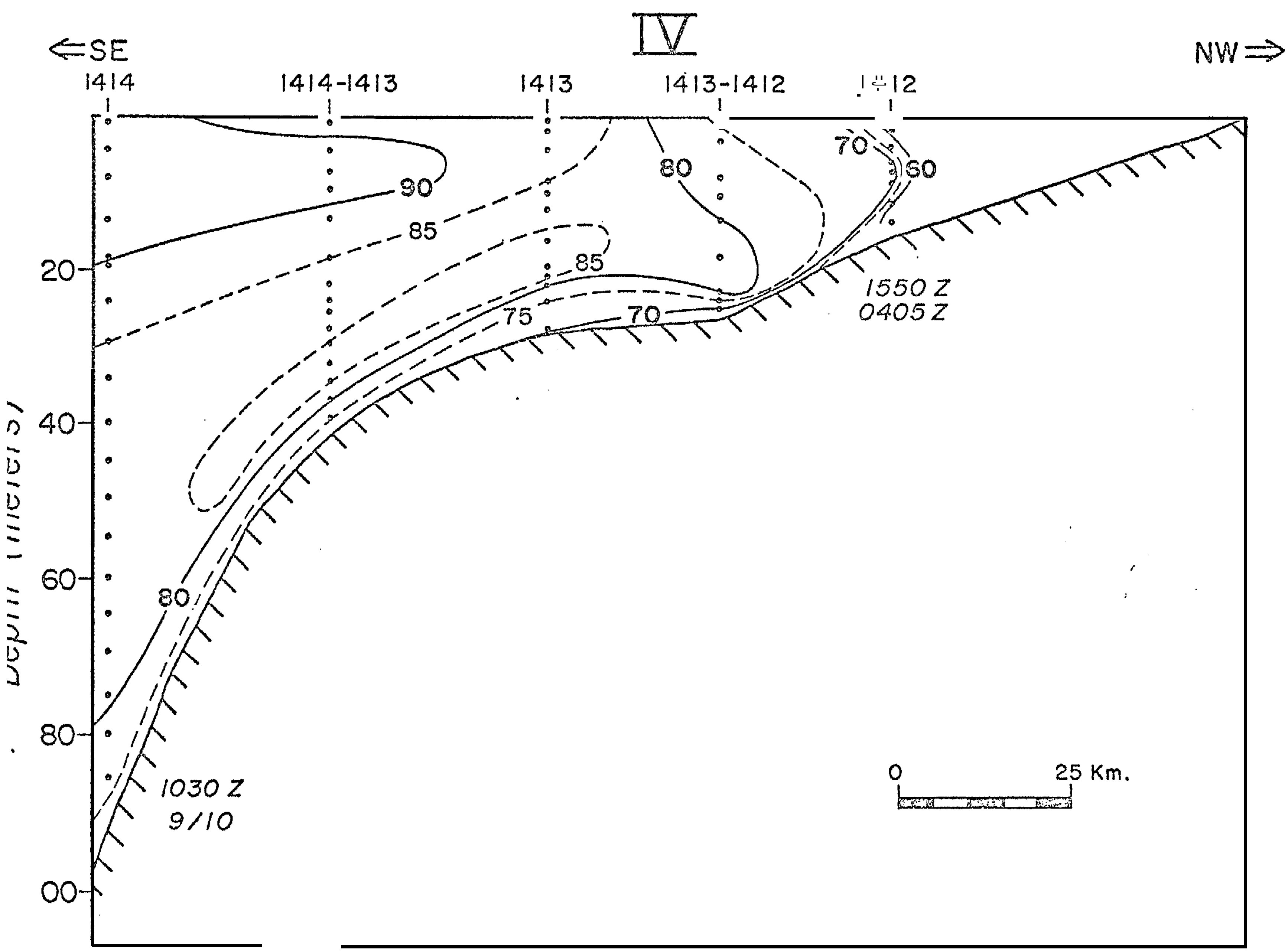


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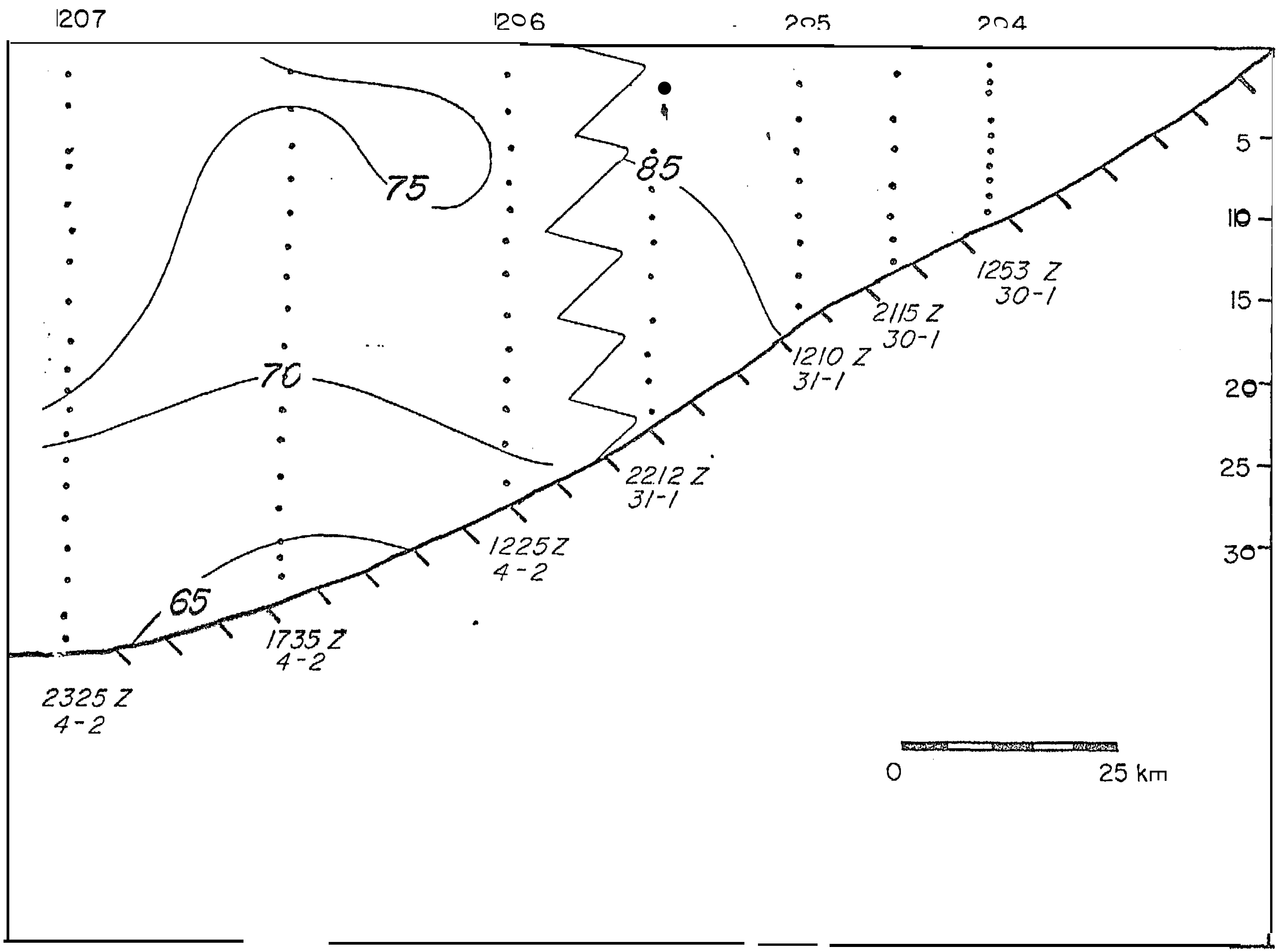
Fig. 8 Transect IV Season II % Transmission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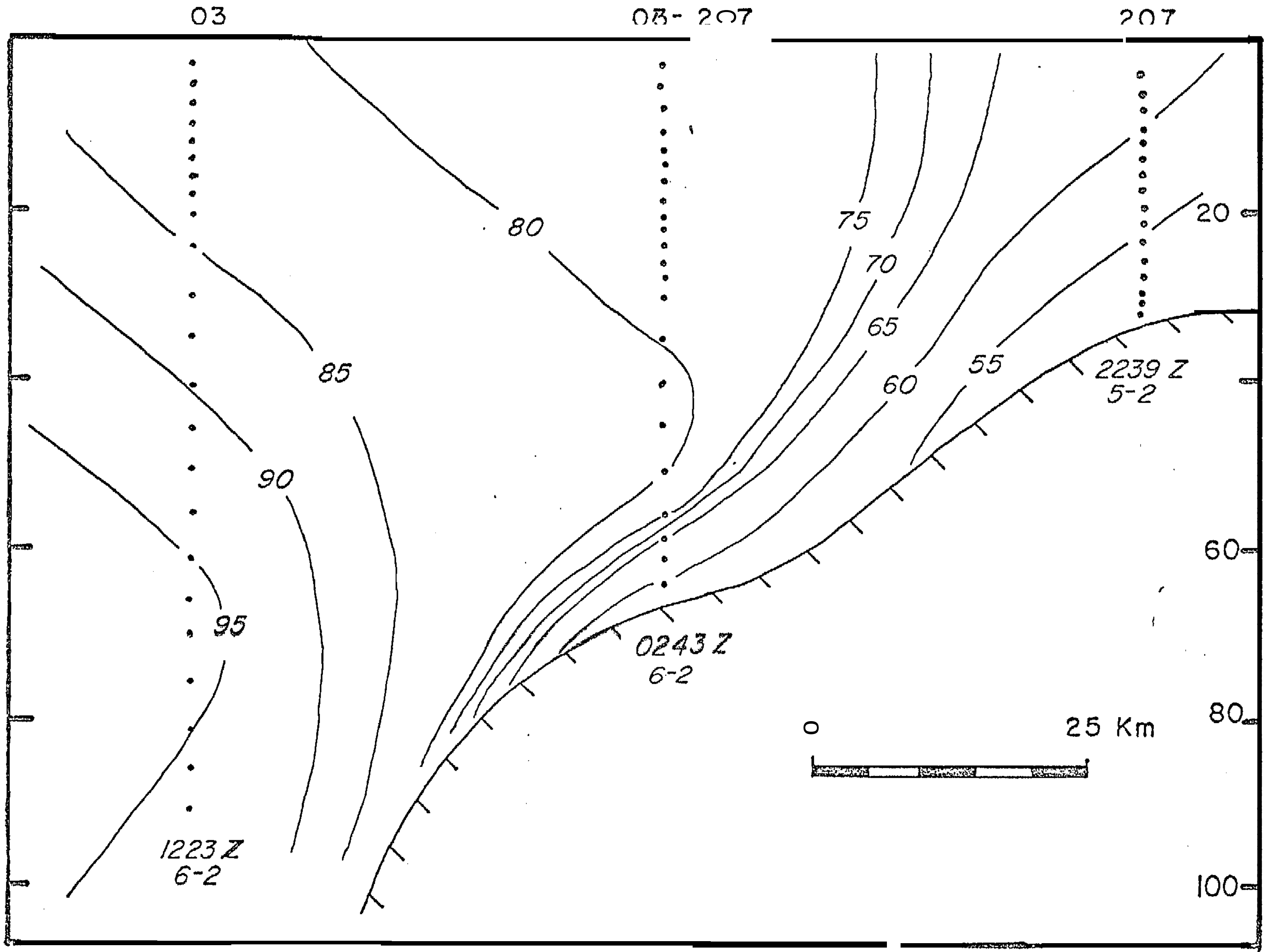
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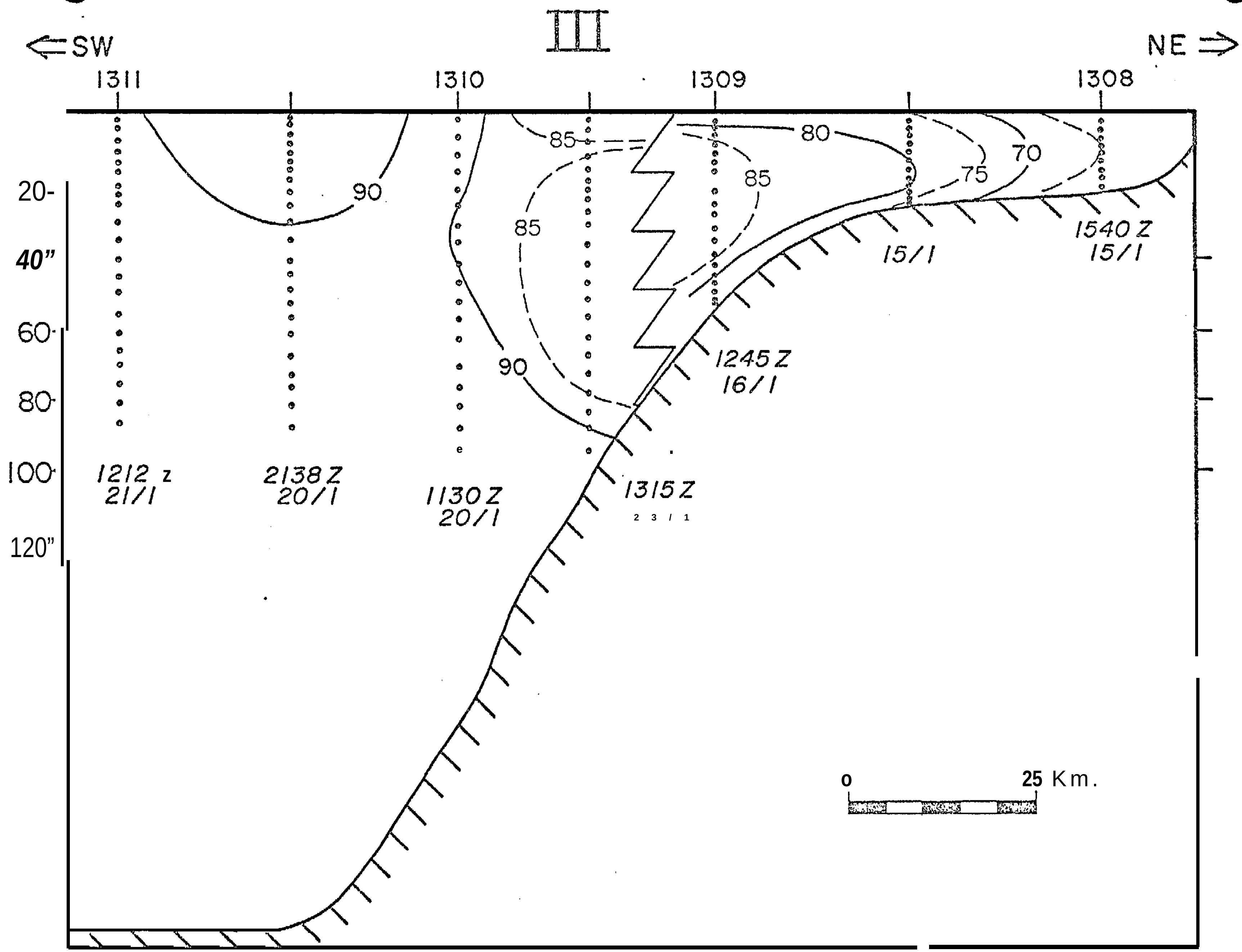


Fig. 12. Transect III., Season III. Note break in time.

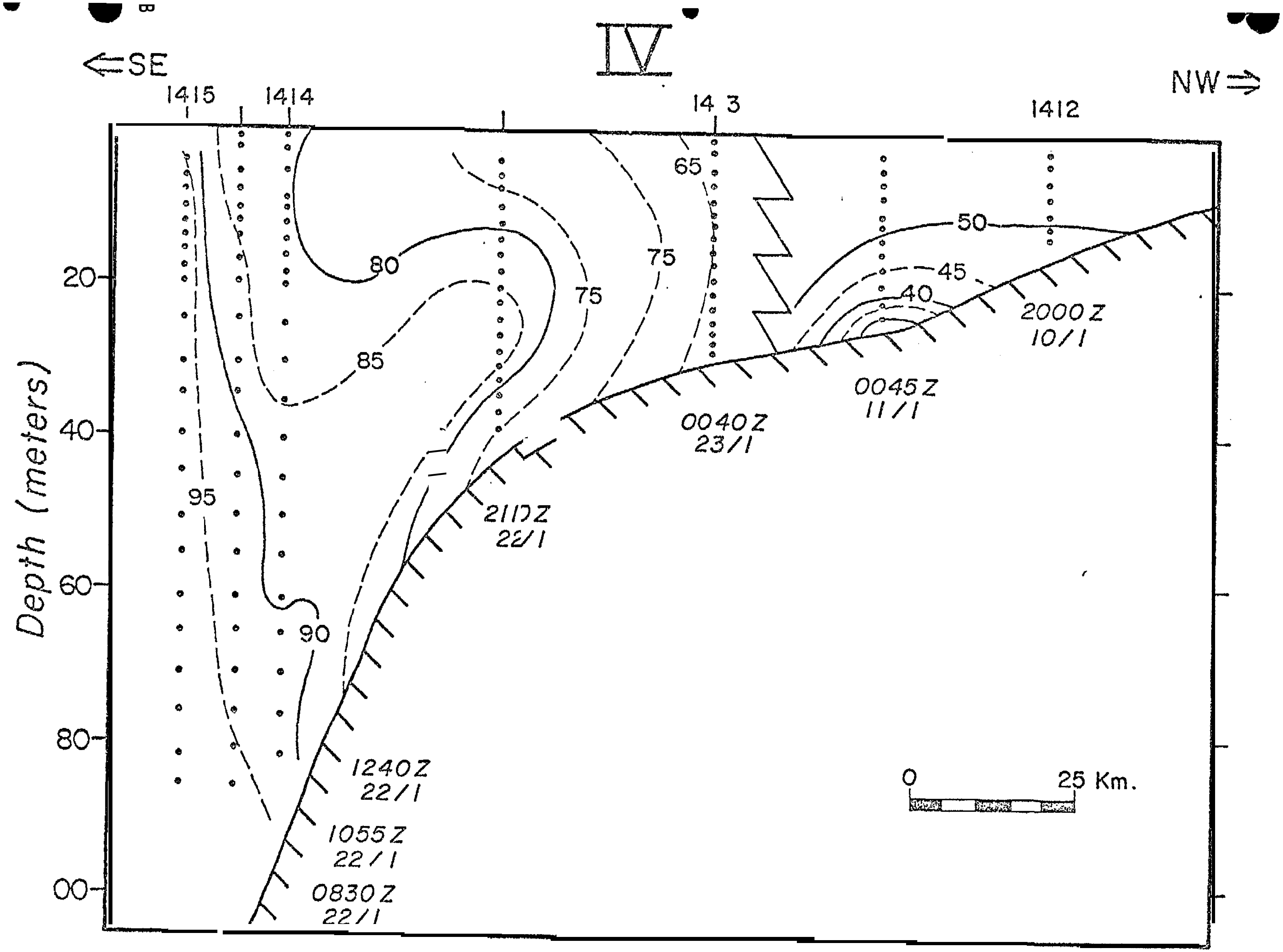


Fig. 13. Transect IV., Season III.

of' particle concentration in the water column, two 24 hr. time series stations were occupied during the fall and winter seasons: One at the Middle Grounds (1207) and one near the Mississippi Delta (1412). The temporal spacing of casts was about six hours.

Figure 14 depicts the fall time series for the two stations. A near-bottom nepheloid layer, apparently resulting from Hurricane ELOISE, was found at station 1207. This layer may have had a slight, semi-diurnal variation in its thickness. At station 1412 a relatively clear layer appears between turbid water at the surface and near-bottom. The surface water cleared up markedly with time, perhaps indicating the transport of turbid Mississippi plume water away from this station. Near-bottom turbidity remained constant, with only the layer thickness changing with time.

Figure 15 shows two winter sequences for the same stations. At station 1207 a nepheloid layer intensified and then faded during the 24 hr. period, but a much longer record is needed in order to consider whether periodic forcing functions could be responsible. The delta series (Station 1412) depicts a turbid water column with little variation in time.

Particulate matter distributions

Transmissivity measurements do not correlate uniquely with suspensate weights or particle counts in ocean waters, owing to the individual effects of particle size, shape, specific gravity, and refractive index. However, since particle properties normally vary transitionally for non-living particulates that make up the bulk of seston, it is possible to interpolate suspended matter by weight (SPM) values from the transmissivity measurements, if sufficient calibration points of SPM measurements are available. The

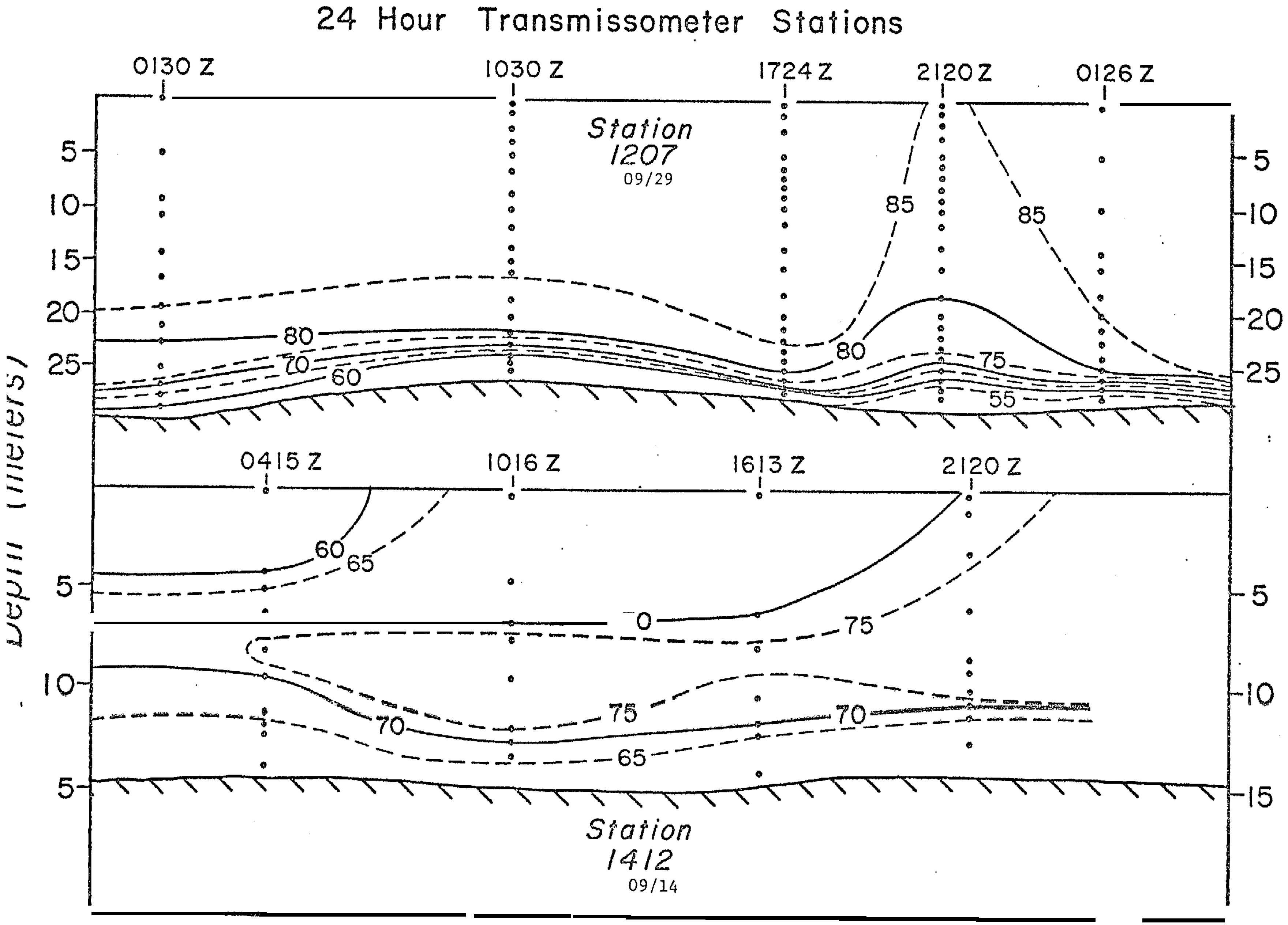
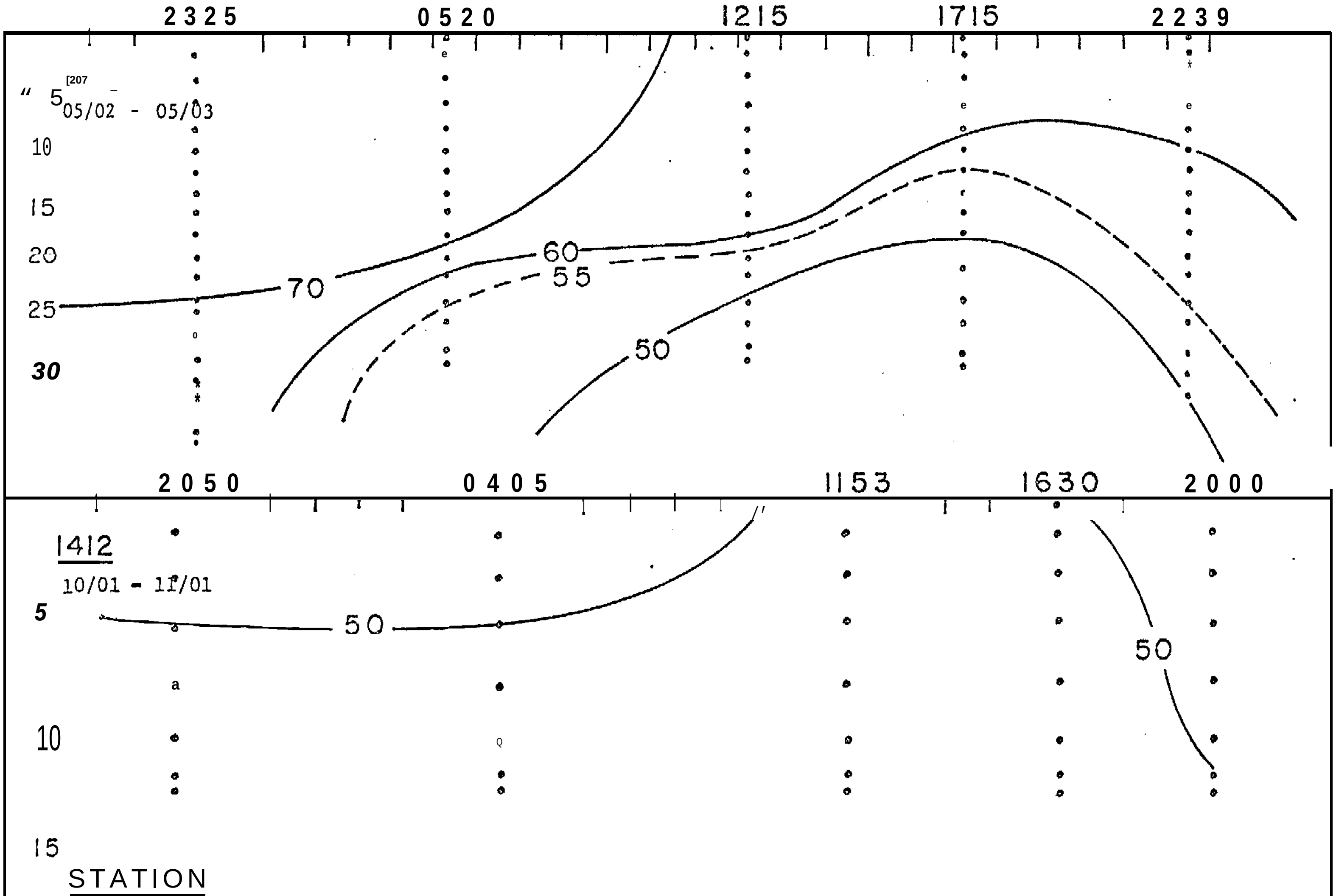


Fig. 14. 24 hour time series. Season II (Sept, 1975).



24-HOUR WINTER TIME SERIES

errors involved in such interpolation appear for the present case not to exceed the fluctuations relating to time delays (sequentiality) in coverage of the stations.

Using SPM calibration of transmissivity data aided by visual inspection of filters, a map of SPM in surface water of the MAFLA area has been prepared for the September, 1975 period (Figure 16). The map clearly demonstrates progressive decrease in particulate concentrations with distance from shore, with an interesting, more homogeneous zone in the vicinity of the Middle Ground.

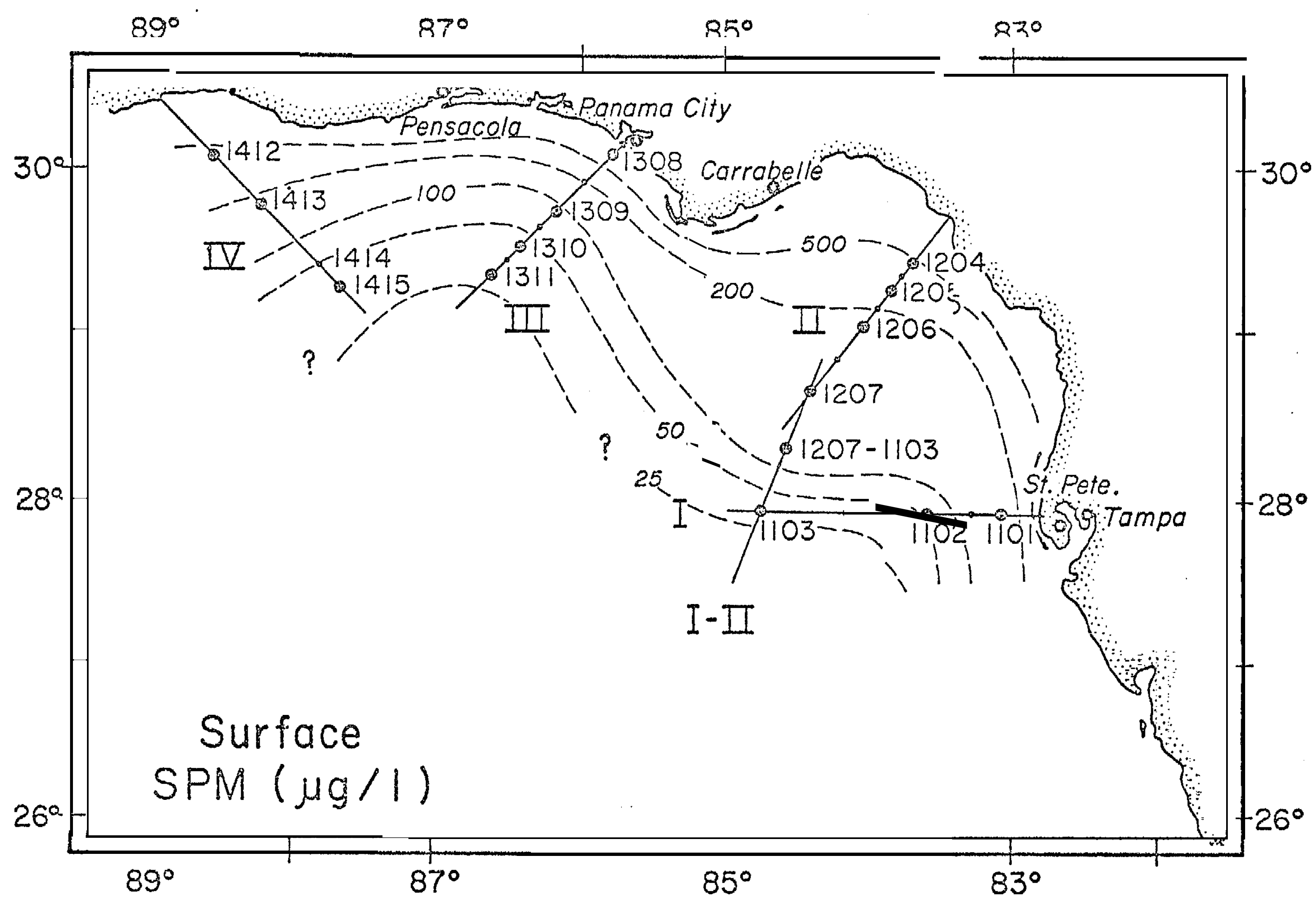


Fig. 16. Particulate distributions in surface waters of Eastern Gulf of Mexico shelves. Contours in μg/l, based on transmissometry and data of Betzer (1976)

DISCUSSION

Seasonal relationships

Some seasonal trends can be easily seen by comparing Figures 4 - 8 with Figures 9 - 13, respectively. In general- the fall data-reveal the effects of water column stratification with often quite clear-water (e.g. % T>85%) overlying near-bottom nepheloid layers resulting from interaction of currents with the bottom. The only exceptions to these general trends were observed in the shallower stations just prior to and after Hurricane ELOISE (Figure ***5),*** where well-mixed, turbid water columns were found. The winter data reveal much more turbid, often well-mixed water columns having transmissivities never exceeding 55% for some of the shallower stations. In fact only at the stations over the slope were transmissivity values exceeding 90% found. As one would expect, the winter data appeared to have been strongly influenced by the lack of water column stability brought on by the succession of windy cold fronts passing through during this season. As a matter of incidental interest, a project to collect certain sponge species in shelf regions had to be delayed through the entire winter season until May (early spring season) owing to turbidity too great to permit divers to observe bottom fauna, Regular checks confirmed the absence of any significant periods of water clarity beyond the sampling cruise in question. Some typical profiles of attenuation coefficient may be seen in Figures 17 and 18.

Turbidity distribute.ons and their relation to water column structure and water mass movements

Many authors have reported the accumulation of particles at density interfaces, especially at the top of the pycnocline. Jerlov ***(1959)*** attributed

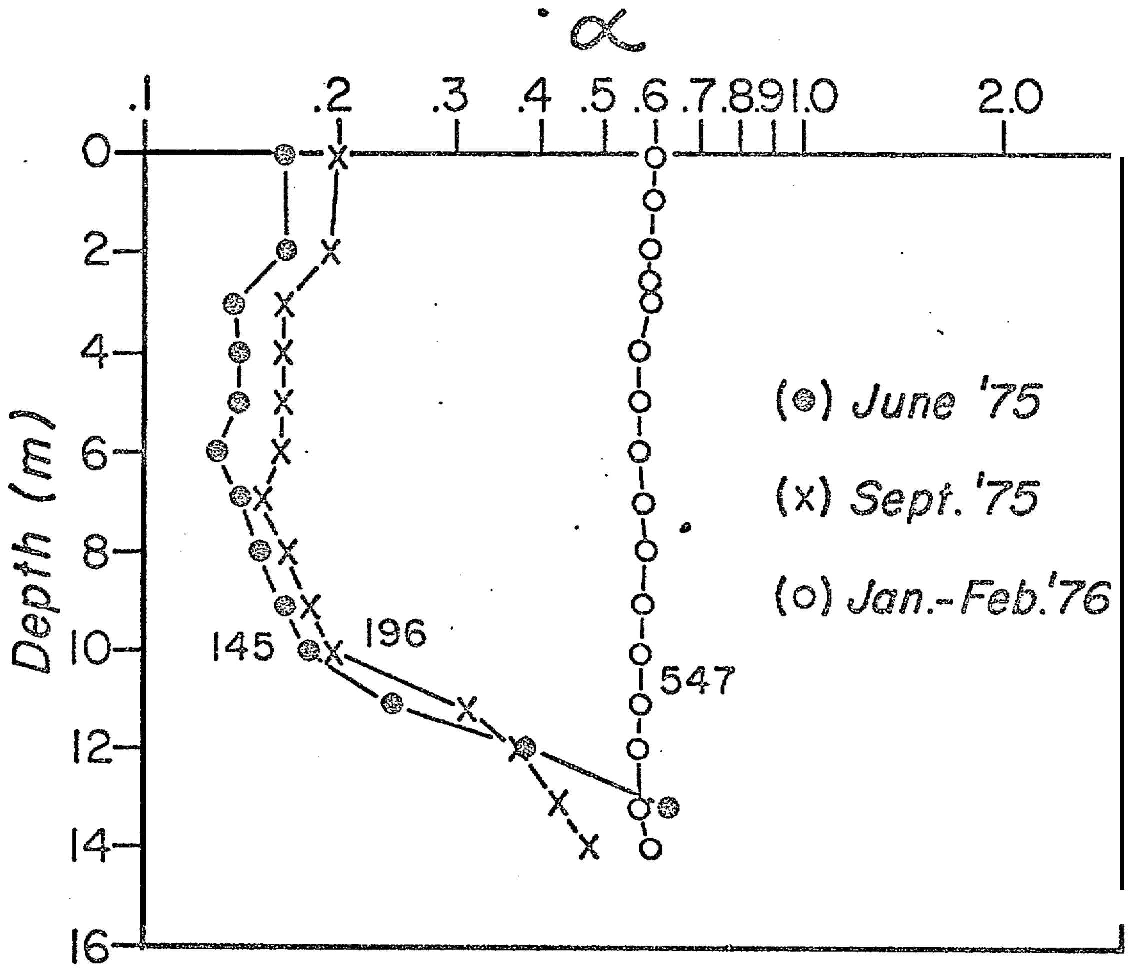


Fig. 17. Transmissometry traces for summer, fall, and winter, Station 1101, off ClearWater Fla. α refers to attenuation coefficient. Included are the SPM values at 10 m depth.

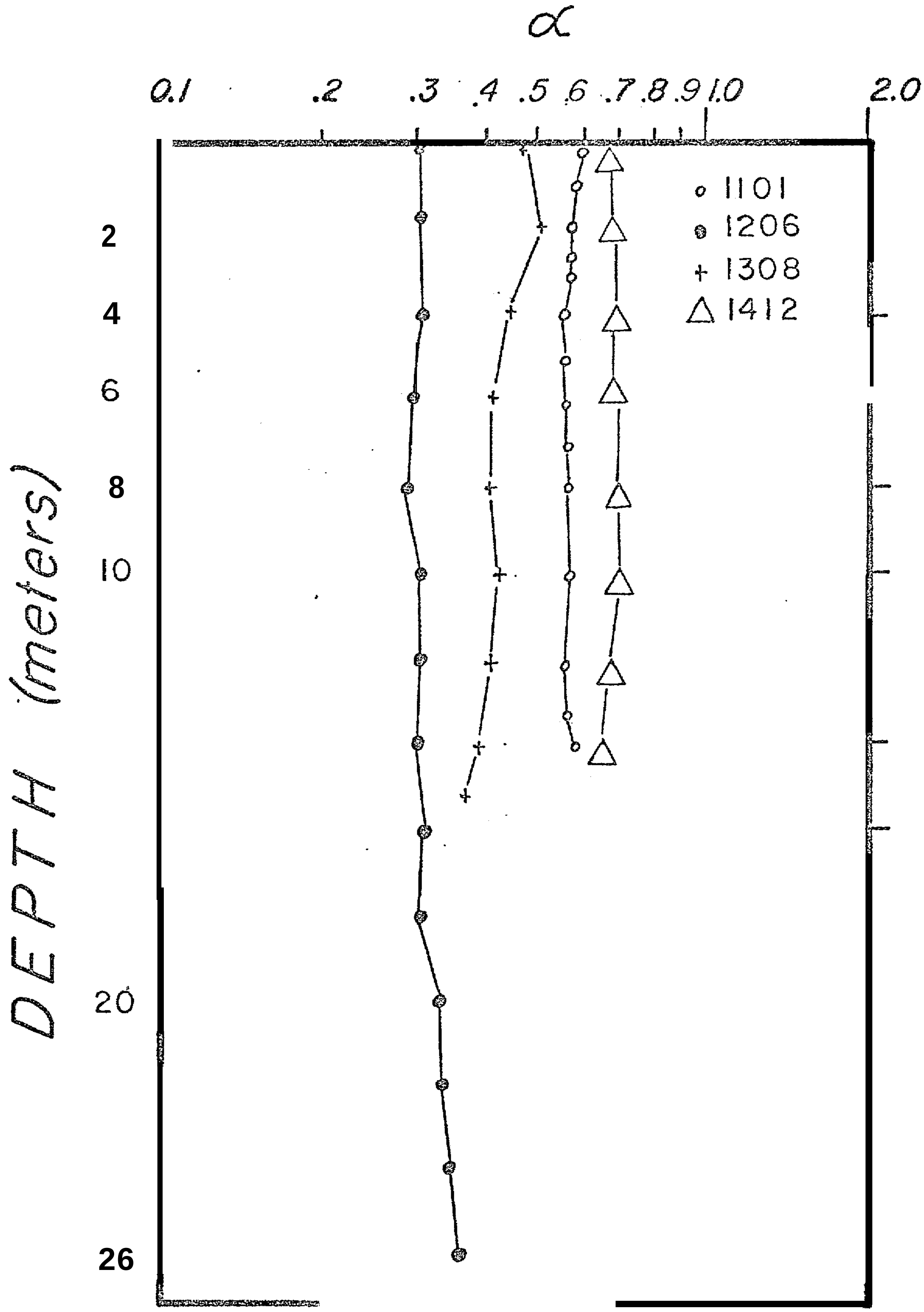


Fig. *18.* Plot of attenuation coefficients for typical station during Jan-Feb., 1976.

this phenomenon to the reduced mixing at that point as well as the increase of water density with depth. Usually, the particles are predominantly organic, and large concentrations are likely to accumulate if the pycnocline starts in the euphotic zone (i.e. , phytoplankton). With the establishment of a thermocline, particles are "trapped" and many phytoplankters are unable to migrate across the pycnocline (Bogorov, 1.958; Raymont, 1963). This is evident in the sharp zone of increased turbidity at the halocline in Figure 2. To various degrees similar features have been observed elsewhere in the world ocean as indicated by studies in the Gulf of California (Kniefer and Austin, 1974), the Irish Sea (Heathershaw and Simpson, 1974), off Mission Beach, California (Ball and LaFond, 1964), and in the eastern Gulf of Mexico (Carder and Schlemmer, 1973).

A near-bottom nepheloid layer is indicative of turbulence in the bottom water. This turbulence is usually caused either by the shear induced by the bottom on an overlying current, or by the interaction of wave-induced water motion with the bottom. Figure 19 provides an example of a near-bottom nepheloid layer that has been induced at least in part by a bottom current. Notice that the temperature and salinity are homogeneous from the bottom to about five meters above the bottom. This region also contains the major portion of the turbid matter. The SPM values associated with the 24% transmission value near the bottom would correspond to 1.58/m = α or roughly 2.2 mg/ℓ (see Figure 3).

The entire water column was quite turbid, indicating that particles were being mixed all the way to the surface. If this turbidity profile had been the direct result of wind alone, the water column would have been vertically homogeneous in temperature and salinity. Hence we conclude the profile was caused by a bottom current, perhaps in combination with wind waves.

Figure 20 provides an example of a well-mixed water column resulting from turbulence which was probably largely wave induced. Here the temperature and salinity values are uniform with depth, and the nepheloid layer extends all the way to the surface. Its turbidity is higher near the bottom since the upward mixing of particles is offset by downward settling. If a steady state existed for the particle concentrations at all depths, then a balance would have been established between the upward flux of particles caused by turbulent diffusion and the downward flux of particles caused by settling. This would have resulted in an exponential decrease in concentration of particles or α (increase in percent transmission) with distance above the bottom for a given particle size, shape and density. Such a distribution approximates the shape of the transmissivity curve in Figure 20. For small, low-density particles the curve could become nearly uniform with depth, given sufficient turbulence. For larger, denser particles,. a rapid decrease in concentration with distance above bottom would be expected.

The particle content of a water column is often indicative of its history. Figure 21 demonstrates a very well-defined, turbid, and well-mixed layer between 185 and 215 m. This layer appears to have been in contact with the bottom at some prior time. The per cent transmission minimum is not an instrumental effect since both down and up traces repeated the pattern.

The net result of such mechanisms as phytoplankton productivity, river plumes, and sediment erosion often results in particulate distribution patterns quite similar to those for salinity and/or temperature. For example, the % T patterns in Figure 22a parallel almost exactly the temperature trends

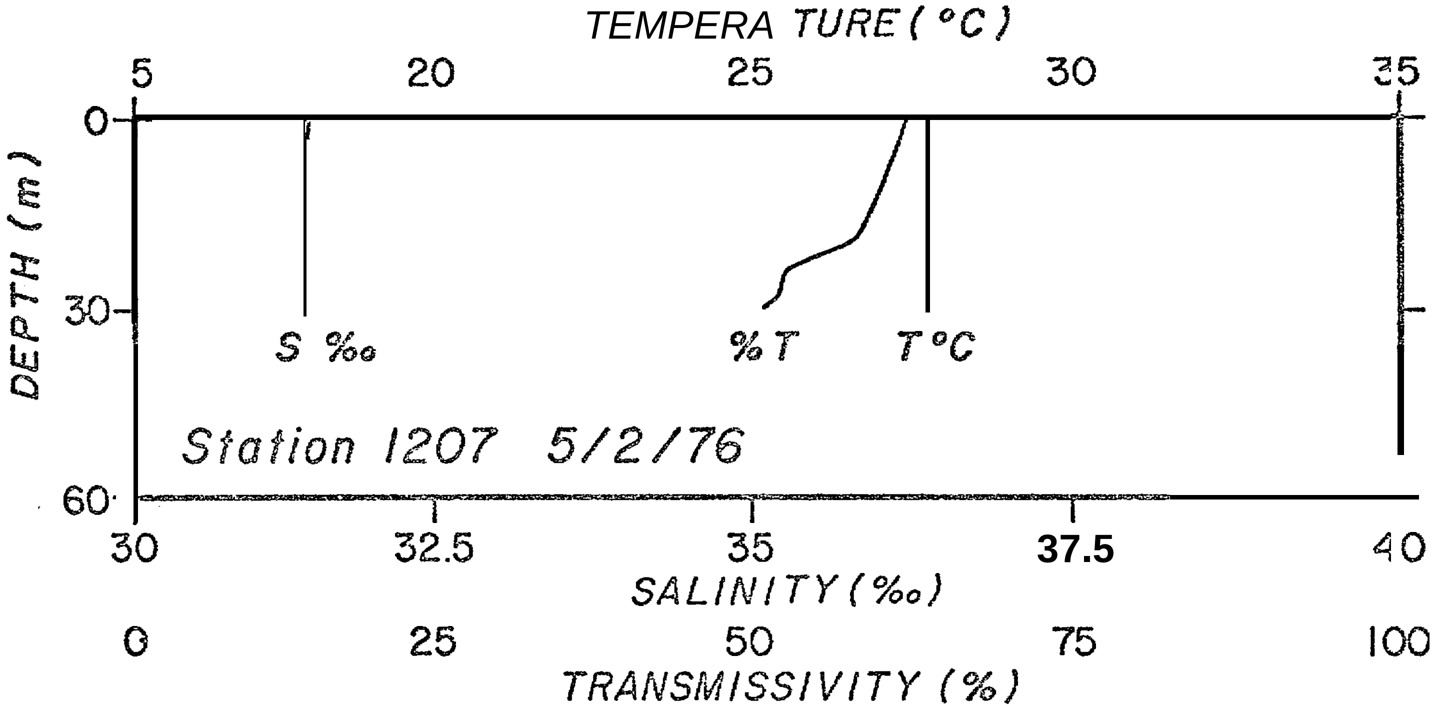


Fig. 19. (Upper Figure) T*C, S(°/oo) and T(%) profiles for a well-mixed water column. S. T data courtesy M. Rinkel.

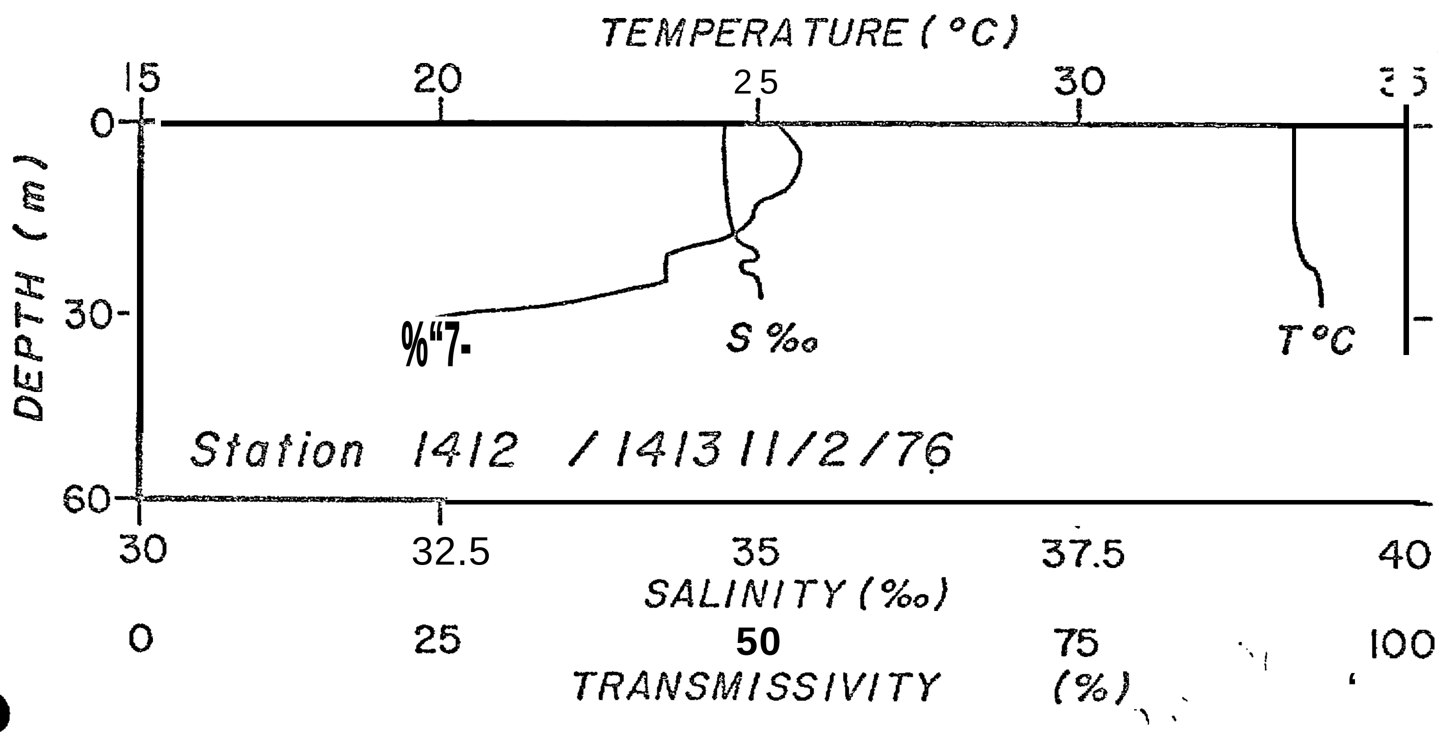


Fig. 20. (Lower Figure) T*C, S (°/oo) and T(%) profiles for a partly stratified water column.

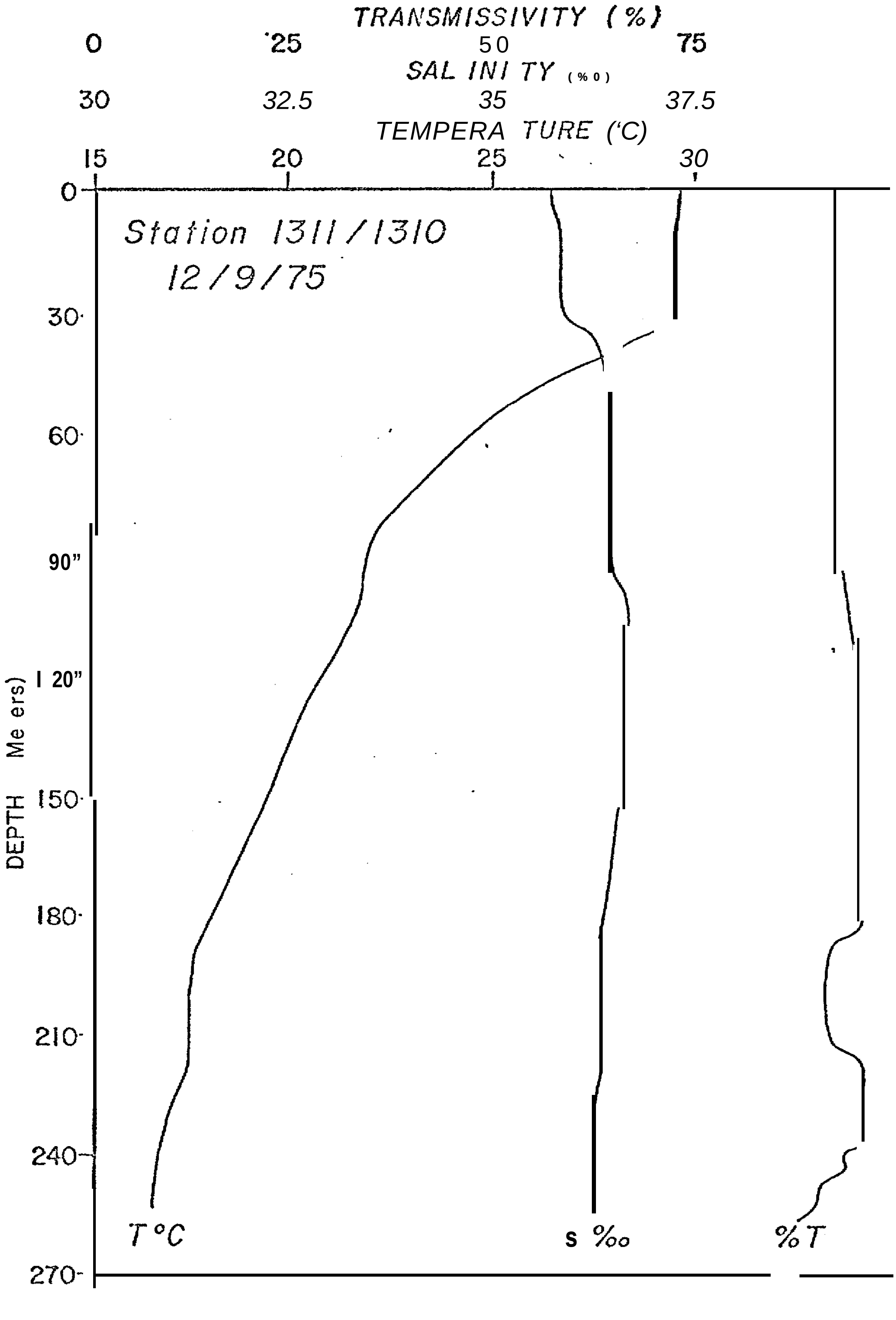
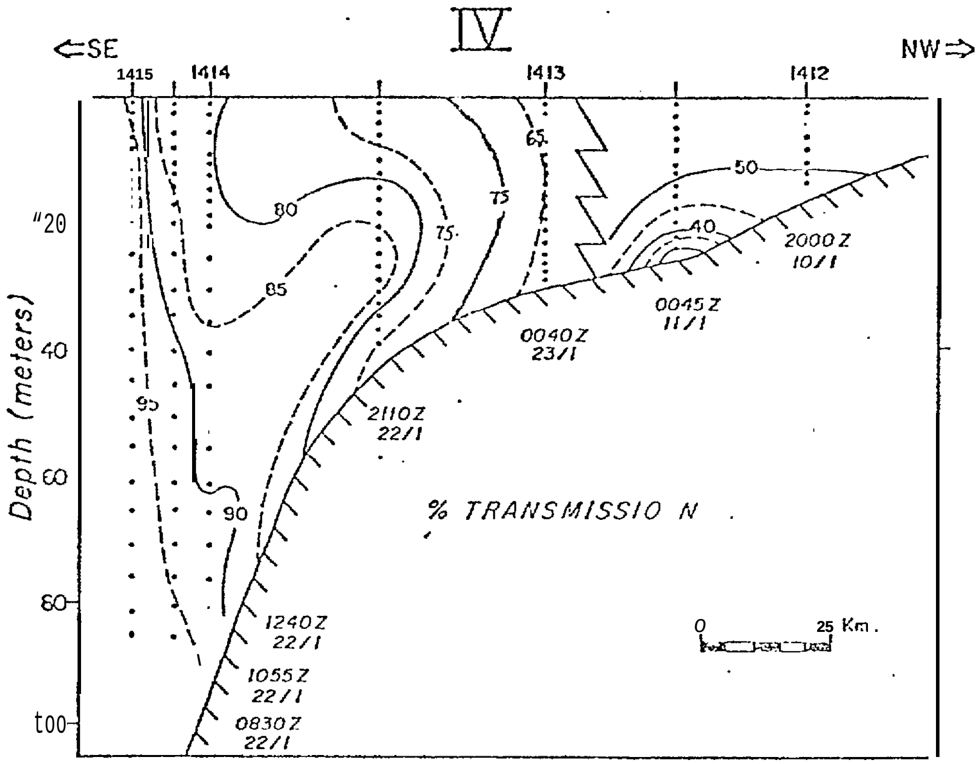


Fig. 21, Vertical profile of Transmissivity (%), Salinity and temperature at Station 1311/1310, Fall sampling season. Note anomalous feature at about 200 m depth, and flattening . . . [illegible]



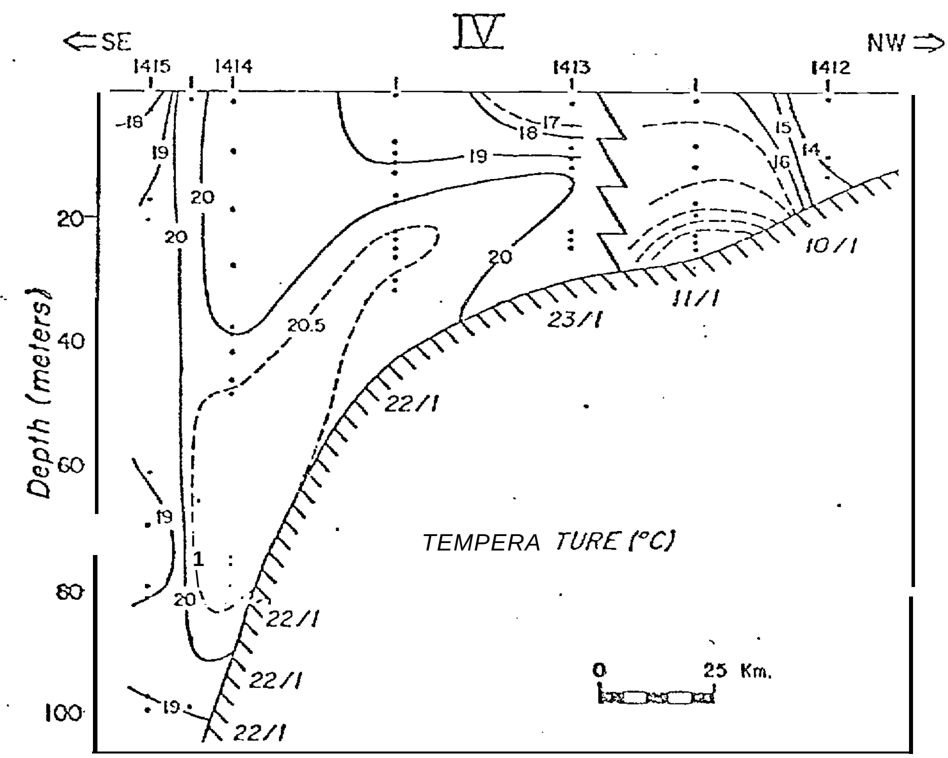


Fig. 22. Transmissivity and temperature distributions for Station IV. Winter Cruise, 1976. Note time break indicated by zig-zag lines.

shown in Figure 22b. This apparently is the result of warm off-shore being also clear relative to Mississippi Delta water. Other such similarities exist between % T and temperature and/or salinity distributions as illustrated in the next section.

Hurricane ELOISE and turbidity-water mass relationships

The eye of Hurricane ELOISE hit landfall at 0630 hours, September 23, 1975 just west of Panama City, Florida (Data of Naval Coastal Systems Laboratory). Transect II was traversed three days after the hurricane, with temperature, salinity and transmissometer measurements included in the sampling program. Some of the results are depicted in Figures 23a, 23b, and 23c, showing salinity, σ_t and per cent transmission sections, respectively.

The inshore waters were vertically well-mixed and turbid while extreme stratification occurred at station 1206/1207. A turbid lens of cold, saline water was found on the bottom. This lens was much more dense ($\Delta\ \sigma_t = 1.2$) than the adjacent (seaward) water. Such dense water would normally be expected to flow downhill; however, if it had sufficient long-shore momentum (induced by the Loop Current, for instance), the landward acceleration associated with its vertical vorticity component could cause it to become a contour current. Thus , in seeking deeper waters it would probably flow generally along the shelf, crossing depth contours obliquely. Similar lenses of low temperature and high salinity have been found on the west Florida shelf when hurricanes have not been present (SUSIO, 1975), but such lenses were not nearly so dense nor so isolated from the Loop Current as the one discussed above. Thus the hurricane appears to have enhanced a phenomenon which could be occurring each summer. 'The cool, saline nature of the water in question suggests that it was a remnant of Loop water which

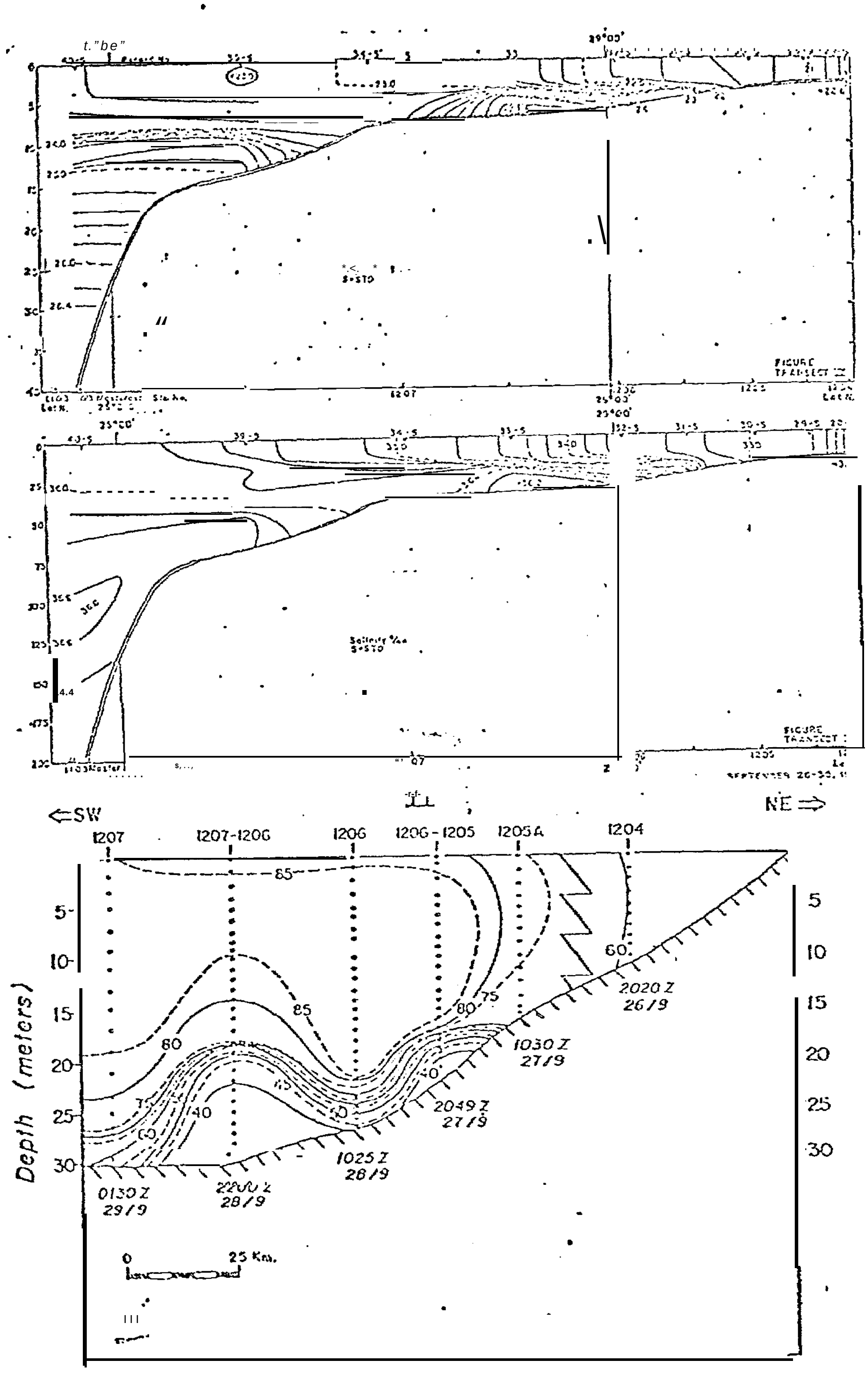


Fig. 23. Comparison of transmissivity and physical oceanographic parameters (σ_t and S) Transect II, Fall season, immediately after Hurricane Eloise, Sept. 1975.

had been upwelled and stranded from the Loop Current, perhaps at some point near the De Soto Canyon. It then may have progressed as a contour current driven by its increased density.

The magnitude of the flow can be estimated to some extent by the fact that the transmission values of the lens had a minimum of about 39% T, corresponding to SPM values of about 1.5 mg/ℓ (Figure 3). For such enrichment ir particulate matter to occur in a region not overly populated by fine sediments suggests that the currents involved may have exceeded one knot (54 cm/see). Visual evidence of scour and rearrangement of bottom organisms by epifaunal investigations (T. E. Hopkins, oral communication) confirmed this concept. For comparison, nepheloid layers associated with the Guiana Current have been reported by one of us (K. L. C.) to have SPM values of 700 μg/ℓ resulting from erosion due to 35 - 40 cm/sec currents.

A subsequent time series took place at Station 1207 (Figure 14) where the turbid, dense lens reappeared about 12.5 hr after appearing at Station 1206 - 1207 (Figure 5). This trend is even more apparent in the STD data of M. Rinkel. This indicates that the core of the flow traveled 26 km in 12.5 hr or about 2 km/hr, or 56 cm/sec seaward, which would be only one component of the flow.

Such. high water velocities are certainly compatible with the values of suspended particulate matter found in the nepheloid layer. Such currents are clearly capable of rearranging the distribution of fine sediments on the middle to outer shelf regions and transporting fine particles rather large distances.

Relationships to hydrocarbon and trace metal distributions in particulate matter, and other environmental implications

The seasonal patterns of turbidity distribution have been commented on earlier. These and regional patterns have critical bearing on interpretation of chemical measurements of particulate properties. During the winter (January - February, 1976) season wind-wave, top-to-bottom mixing was extensive in the inshore stations. Only approaching the outer shelf and slope did. clearer water of the type noted closer to shore during summer and fall appear. Moreover, the rapidity with which new turbid distributions developed even within a few days, as demonstrated by reoccupation of stations, indicates that the sediments in question were of relatively local origin, and are probably fine mobile fractions stirred up from the bottom primarily by wave action. Data of Huang (1976 - this report) confirm this concept in that the mineralogy of the inshore suspensates strongly resembles the mineralogy of bottom sediments, and includes significant concentrates of carbonate minerals such as high and low magnesium carbonates and dolomite in given areas. Related observations were made by Hopkins (1976 - this report) in suggesting that the repeated effects of winter storms may exert a stronger erosive effect on the Middle Ground and its organisms than a few yearly events of hurricane force.

The significance of these observations is that during wind-agitated periods in winter, water samples in the middle of the water column probably represent the total water column quite representatively with respect to particulate matter and perhaps phytoplankton, chlorophyll and related measurements as well..

Not only does sampling water column particulate provide a representative sampling for the water column, but it offers a rapid integrated sample of fine bottom particulate for local areas during turbulent periods. Based on results from bottom sediment trace metal and particulate trace metal values in MAFLA baseline studies for 1974 - 75 (Presley, 1975; Betzer, 1975) we may presume that significant proportions of particulate trace metals for the winter season originate from the fine, mobile fraction of bottom sediments in inshore waters. It has not yet been possible to study hydrocarbon in particulate in detail for relationship to overall turbidity distribution; however, one would predict a significant relationship to detrital or degraded biogenic hydrocarbons derived from the fine mobile fraction of bottom sediments.

It is unfortunately not possible to estimate the percentage of particulate matter comprised by organic matter quantitatively, since comparison of SPM and POC shows POC values frequently exceeding SPM by considerable margins. Systematic errors in particulate determination virtually always occur on the high side; for this reason, and because the available SPM values agree well with transmissometry - SPM data from other areas, we conclude that the available particulate organic carbon (POC) data must be too high owing to some systematic factor.

For the summer-fall water column the picture is entirely different than the winter, owing to the significant transparency of the water column, and the strong vertical gradients in turbidity distributions. It is expected that at ten meters particulate organic carbon may well predominate over terrigenous or mineral detritus in these waters, and may be a result of long distance transport depending on physical oceanographic, meteoric and

P

other conditions. A single sample at ten meters or any other arbitrary depth will not be representative of the water column. However, depending on shelf water depth and complexity of particulate distributions, two or three samples may provide adequate characterization of particulate, if sampling depths are chosen after preliminary examination of turbidity distributions. For example, in Transect I, Season II at least two samples, one in the clear water column and one in the bottom nepheloid zone would be needed to determine end member composition of the suspensates, and permit estimation of intermediate values if needed. Similar arguments would apply for the Rig Monitoring, where turbidity additions could be complex depending on local currents and turbidity regimes.

The turbidity distributions also have implications for coagulation and removal of oil slicks from the column by coascervation, zooplankton sweeping, and aggregation of detrital particles with adsorbed oil and subsequent sinking to the bottom. Such removal should be two to ten fold greater during winter than during the summer well-stratified periods.

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Appendix 1

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD I

STD	DEPTH(M)	% TRA	BETWEEN	STNS
~~M*01~~	~~12.00~~	~~79.00~~	~~1204~~	1205
M*02	0.0	78.00		
M*02	2.00	81.00		
M*02	3.00	82.00		
~~M*02~~	~~[illegible]~~	~~[illegible].00~~		
M*02	[illegible].00	82.00		
M*02	6.00	82.00		
M*02	7.00	79.00		
~~M*02~~	~~8.00~~	~~79.00~~		
M*02	9.00	78.00		
M*02	10.00	78.00		
M*02	11.00	77.00		
~~[illegible]~~	~~12.00~~	~~77.[illegible]~~		
M*02	13.00	76.00		
M*02	14.00	75.00		
M*02	15.00	75.00		

STD	DEPTH(M)	% TRANS	BETWEEN	STNS
~~M*04~~	~~0.0~~	~~67.00~~	~~1205~~	1206
M*04	2.00	70.00		
M*04	4.00	72.00		
M*04	6.00	70.00		
~~M*04~~	~~8.00~~	~~71.00~~		
M*04	10.00	70.00		
M*04	14.00	71.00		
M*04	16.00	67.00		
~~M*04~~	~~18.00~~	~~67.00~~		
M*04	20.00	67.00		
M*04	22.00	65.00		
M*04	24.00	67.00		

B

E

DMSAG FILE 0221
ON-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD I

SID	DEPTH(M)	% TRANS	STN
MW01	0.0	76.00	1204
MW01	2.00	80.00	
MW01	3.00	80.00	
MW01	4.00	81.00	
MW01	5.00	81.00	
MW01	6.00	82.00	
MW01	7.00	82.00	
MW01	8.00	82.00	
MW01	9.00	82.00	
MW01	10.00	81.00	
MW01	11.00	80.00	
MW03	0.0	91.00	1205
MW03	2.00	91.00	
MW03	4.00	92.00	
MW03	6.00	92.00	
MW03	8.00	92.00	
MW03	10.00	92.00	
MW03	12.00	93.00	
MW03	14.00	90.00	
MW05	0.0	85.00	1101
MW05	2.00	85.00	
MW05	3.00	87.00	
MW05	4.00	87.00	
MW05	5.00	87.00	
MW05	6.00	88.00	
MW05	7.00	87.00	
MW05	8.00	86.00	
MW05	9.00	85.00	
MW05	10.00	84.00	
MW05	11.00	79.00	
MW05	12.00	68.00	
MW05	13.00	54.00	

D

DMSAG FILE 0221
ON-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD II

SID	DEPTH(M)	% TRANS	STN
HP01	5.00	93.00	1414
HP01	10.00	92.00	
HP01	15.00	91.00	
HP01	20.00	89.00	
HP01	25.00	87.00	
HP01	30.00	85.00	
HP01	35.00	83.00	
HP01	40.00	83.00	
HP01	45.00	83.00	
HP01	50.00	83.00	
HP01	55.00	84.00	
HP01	60.00	85.00	
HP01	65.00	84.00	
HP01	70.00	83.90	
HP01	75.00	82.00	
HP01	80.00	79.00	
HP01	85.00	77.00	
MW11	0.0	59.00	1311
MW11	10.00	52.00	
MW11	20.00	53.00	
MW11	25.00	53.00	
MW11	30.00	52.00	
MW11	40.00	54.00	
MW11	50.00	55.00	
MW11	65.00	56.00	
MW11	75.00	56.00	
MW11	100.00	56.00	
MW11	110.00	56.00	
MW11	125.00	56.00	
MW11	130.00	56.00	
MW11	140.00	55.50	
MW11	145.00	56.50	
MW11	150.00	53.00	
MW11	155.00	54.00	
MW11	158.00	53.00	
MW11	160.00	52.00	
MW12	6.00	48.00	
MW12	10.00	50.00	
MW12	20.00	50.50	
MW12	30.00	50.00	
MW12	35.00	50.00	
MW12	40.00	50.50	
MW12	50.00	51.00	
MW12	60.00	51.00	
MW12	65.00	50.50	
MW12	70.00	51.00	
MW12	90.00	53.00	
MW12	105.00	53.50	
MW12	110.00	53.50	
MW12	135.00	53.00	
MW13	0.0	49.00	1310
MW13	10.00	40.00	
MW13	20.00	49.00	
MW13	30.00	49.00	
MW13	40.00	50.00	
MW13	45.00	50.00	
MW13	55.00	50.00	
MW13	65.00	51.00	
MW13	70.00	51.00	
MW13	75.00	51.00	
MW13	80.00	51.50	
MW13	90.00	52.00	
MW13	100.00	52.00	
MW13	105.00	51.00	
MW13	110.00	50.00	
MW13	115.00	48.00	
MW13	120.00	46.00	
HP03	0.0	59.00	1204
HP03	1.00	59.00	
HP03	3.00	59.00	
HP03	4.00	59.00	
HP03	5.00	59.00	
HP03	6.00	59.00	
HP03	7.00	60.00	
HP03	8.00	60.00	
HP03	9.00	60.00	
HP03	10.00	59.50	
HP05	0.0	75.00	1205
HP05	2.00	75.00	
HP05	3.00	75.00	
HP05	4.00	75.00	
HP05	5.00	75.00	
HP05	6.00	75.00	
HP05	7.00	75.00	
HP05	8.00	75.00	
HP05	9.00	75.00	
HP05	10.00	75.00	
HP05	11.00	76.00	
HP05	12.00	76.00	
HP05	13.00	77.00	
HP05	14.00	77.00	
HP05	15.00	77.00	
HP05	16.00	77.00	
HP07	1.00	81.00	1206
HP07	2.00	85.00	
HP07	3.00	870.00	
HP07	4.00	87.00	
HP07	5.00	88.00	
HP07	6.00	88.00	
HP07	7.00	88.00	
HP07	8.00	88.00	
HP07	9.00	88.00	
HP07	10.00	86.00	
HP07	11.00	89.00	
HP07	12.00	88.00	
HP07	13.00	88.00	
HP07	14.00	87.00	
HP07	15.00	88.00	
HP07	16.00	88.00	
HP07	17.00	88.00	
HP07	18.00	88.00	
HP07	19.00	88.00	
HP07	20.00	88.00	
HP07	21.00	87.00	
HP07	22.00	79.00	
HP07	23.00	68.00	
HP07	24.00	55.00	
HP07	25.00	50.00	
HP07	26.00	46.00	
HP09	1.00	85.00	1207
HP09	2.00	86.00	
HP09	3.00	87.00	
HP09	5.00	87.00	
HP09	7.00	87.00	
HP09	9.00	86.50	
HP09	11.00	87.00	
HP09	13.00	87.00	
HP09	15.00	87.00	
HP09	17.00	85.00	
HP09	19.00	85.00	
HP09	21.00	83.50	
HP09	23.00	80.00	
HP09	25.00	81.00	
HP09	27.00	69.00	
HP09	29.00	58.00	

HP10	1.00	87.00
HP10	2.00	89.00
HP10	3.00	89.00
HP10	4.00	89.00
HP10	5.00	89.00
HP10	6.00	89.00
HP10	7.00	89.00
HP10	8.00	89.00
HP10	9.00	89.00
HP10	10.00	89.00
HP10	12.00	89.00
HP10	14.00	88.00
HP10	16.00	85.00
HP10	18.00	81.00
HP10	20.00	83.00
HP10	22.00	80.00
HP10	23.00	64.00
HP10	24.00	57.00
HP10	25.00	57.00
HP11	1.00	88.00
HP11	2.00	87.00
HP11	3.00	87.00
HP11	4.00	87.00
HP11	6.00	87.00

HP11	7.00	87.00
HP11	8.00	87.00
HP11	9.00	87.00
HP11	10.00	87.00
HP11	12.00	87.00
HP11	14.00	87.00
HP11	16.00	87.00
HP11	18.00	89.00
HP11	20.00	87.00
HP11	21.00	86.00
HP11	22.00	85.00
HP11	23.00	85.00
HP11	24.00	84.00
HP11	25.00	83.00
HP11	27.00	65.00
HP12	1.00	83.00
HP12	2.00	84.00
HP12	3.00	84.00
HP12	4.00	84.00
HP12	5.00	84.00
HP12	6.00	84.00
HP12	7.00	84.00
HP12	8.00	84.00
HP12	9.00	84.00
HP12	10.00	83.00
HP12	12.00	83.00
HP12	14.00	83.00
HP12	16.00	82.00
HP12	18.00	81.50
HP12	20.00	79.00
HP12	21.00	78.00
HP12	22.00	77.00
HP12	23.00	76.00
HP12	24.00	73.00
HP12	25.00	61.00
HP12	27.00	53.00
HP12	28.00	51.00
HP13	1.00	85.00
HP13	3.00	84.00
HP13	4.00	85.00
HP13	5.00	86.00
HP13	6.00	86.00
HP13	7.00	87.00
HP13	8.00	87.00
HP13	9.00	87.00
HP13	10.00	87.00
HP13	12.00	87.00
HP13	14.00	87.00
HP13	16.00	87.00
HP13	18.00	86.00
HP13	20.00	85.00
HP13	21.00	85.00
HP13	23.00	83.00
HP13	24.00	83.00
HP13	25.00	82.00
HP13	26.00	60.00

HP15	1.00	92.00	1103
HP15	5.00	92.00	
HP15	10.00	90.00	
HP15	15.00	92.00	
HP15	20.00	87.00	
HP15	24.00	87.00	
HP15	26.00	87.00	
HP15	28.00	87.00	
HP15	30.00	86.00	
HP15	35.00	87.00	
HP15	40.00	87.00	
HP15	45.00	87.00	
HP15	50.00	87.00	
HP15	55.00	87.00	
HP15	60.00	87.00	
HP15	65.00	87.00	
HP15	70.00	86.00	
HP15	75.00	86.00	
HP17	1.00	90.00	1102
HP17	2.00	91.00	
HP17	3.00	92.00	
HP17	4.00	93.00	
HP17	5.00	92.00	
HP17	6.00	91.00	
HP17	7.00	91.00	
HP17	8.00	91.00	
HP17	9.00	91.00	
HP17	10.00	91.00	

HP17	15.00	92.00	
HP17	20.00	89.00	
HP17	25.00	80.00	
HP17	26.00	78.00	
HP17	27.00	74.00	
HP17	28.00	72.00	
HP17	29.00	70.00	
HP17	30.00	69.00	
HP17	31.00	68.00	
HP 9	1.00	82.00	1101
HP 9	2.00	82.00	
HP 9	3.00	85.00	
HP 9	4.00	85.00	
HP 9	5.00	85.00	
HP 9	6.00	85.00	
HP 9	7.00	86.00	
HP 9	8.00	85.00	
HP 9	9.00	84.00	
HP 9	10.00	82.00	
HP 9	11.00	73.00	
HP 9	12.00	69.00	
HP 9	13.00	65.00	
HP 9	14.00	62.00	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD II

SID	DEPTH(M)	% TRANS	BETWEEN STNS
HP15	1.00	93.00	~~1103~~ 1102
HP15	2.00	92.00	
HP15	3.00	93.00	
HP15	4.00	94.00	
HP15	5.00	94.00	
HP15	6.00	96.00	
HP15	7.00	97.00	
HP15	8.00	97.00	
HP15	10.00	97.00	
HP15	11.00	97.00	
HP15	12.00	97.00	
HP15	13.00	97.00	
HP15	14.00	97.00	
HP15	15.00	97.00	
HP15	17.00	98.00	
HP15	19.00	98.00	
HP15	21.00	98.00	
HP15	23.00	97.00	
HP15	25.00	97.00	
HP15	27.00	97.00	
HP15	29.00	97.00	
HP15	31.00	97.00	
HP15	33.00	96.00	
HP15	35.00	95.00	
HP15	37.00	95.00	
HP15	39.00	95.00	
HP15	41.00	93.00	
HP15	43.00	92.00	
HP15	45.00	92.00	
HP15	47.00	91.00	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
HP14	1.00	88.00	~~1207~~ 1103
HP14	2.00	89.00	
HP14	3.00	87.00	
HP14	4.00	88.00	
HP14	5.00	[illegible]	
HP14	6.00	89.00	
HP14	7.00	89.00	
HP14	8.00	89.00	
HP14	9.00	89.00	
HP14	10.00	89.00	
HP14	12.00	91.00	
HP14	14.00	91.00	
HP14	16.00	92.00	
HP14	18.00	92.00	
HP14	20.00	91.00	
HP14	22.00	92.00	
HP14	24.00	92.00	
HP14	26.00	91.00	
HP14	28.00	92.00	
HP14	30.00	92.00	
HP14	32.00	92.00	
HP14	34.00	92.00	
HP14	36.00	92.00	
HP14	38.00	92.00	
HP14	40.00	91.00	
HP14	45.00	89.00	
HP14	50.00	85.00	
HP14	55.00	85.00	
HP14	60.00	85.00	
HP14	61.00	85.00	
HP14	62.00	85.00	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD II

STD	DEPTH(M)	% TRANS	BETWEEN STNS
~~MW15~~	~~0.0~~	~~[illegible]~~	~~1310~~ 1309
MW15	5.00	49.00	
MW15	10.00	49.00	
MW15	15.00	49.00	
~~MW15~~	~~20.00~~	~~50.00~~	
MW15	25.00	50.00	
MW15	30.00	50.00	

STD	DEPTH(M)	% TRANS	BETWEEN STNS
~~MW12~~	~~145.00~~	~~[illegible]~~	~~1311~~ 1310
MW12	150.00	54.00	
MW12	160.00	54.00	
MW12	165.00	52.00	
~~MW12~~	~~170.00~~	~~51.00~~	
MW12	175.00	50.00	
MW12	180.00	47.00	
MW12	190.00	54.00	
~~MW12~~	~~195.00~~	~~53.50~~	
MW12	200.00	53.50	
MW12	205.00	53.00	
MW12	210.00	52.00	
~~MW12~~	~~212.00~~	~~51.00~~	
MW12	214.00	50.00	
MW12	217.00	44.00	
MW12	219.00	45.00	
~~MW12~~	~~220.00~~	~~[illegible]~~	
MW12	222.00	48.00	
MW12	225.00	47.00	

STD	DEPTH(M)	% TRANS	BETWEEN STNS
~~HP18~~	~~1.00~~	~~85.00~~	~~1102~~ 1101
HP18	2.00	85.00	
HP18	3.00	85.00	
HP18	4.00	85.00	
~~HP18~~	~~5.00~~	~~85.00~~	
HP18	6.00	85.00	
HP18	7.00	85.00	
HP18	8.00	85.00	
~~HP18~~	~~9.00~~	~~87.00~~	
HP18	10.00	87.00	
HP18	11.00	87.00	
HP18	12.00	87.00	
~~HP18~~	~~13.00~~	~~87.00~~	
HP18	14.00	87.00	
HP18	15.00	87.00	
HP18	16.00	87.00	
~~HP18~~	~~17.00~~	~~87.00~~	
HP18	18.00	85.00	
HP18	19.00	77.00	
HP18	20.00	75.00	
~~HP18~~	~~21.00~~	~~72.00~~	
HP18	22.00	71.00	
HP18	23.00	70.00	
HP18	24.00	70.00	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD II

STD	DEPTH(M)	% TRANS	BETWEEN STNS
HP04	0.0	32.50	1204 1205
HP04	1.00	32.50	
HP04	2.00	32.50	
HP04	3.00	32.50	
[illegible]	[illegible]	32.50	
HP04	[illegible]	32.50	
HP04	[illegible]	33.00	
HP04	[illegible]	33.00	
HP04	10.00	33.00	
HP04	11.00	33.00	
HP04	12.00	33.50	
HP04	13.00	33.50	
[illegible]	[illegible]	[illegible]	

STD	DEPTH(M)	% TRANS	BETWEEN STNS
HP05	2.00	84.50	1205 1206
HP05	3.00	85.00	
HP05	4.00	85.00	
HP05	5.00	85.00	
HP05	[illegible]	85.00	
HP05	7.00	85.00	
HP05	[illegible]	85.00	
HP05	[illegible]	85.00	
HP05	10.00	85.00	
HP05	11.00	85.00	
HP05	12.00	85.00	
HP05	13.00	84.50	
[illegible]	14.00	85.00	
HP05	15.00	85.00	
HP05	16.00	85.00	
HP05	17.00	84.00	
HP05	18.00	59.00	
HP05	19.00	42.00	
HP05	20.00	39.00	
HP05	21.00	33.00	

STD	DEPTH(M)	% TRANS	BETWEEN STNS
[illegible]	1.00	[illegible]	1206 1207
HP08	2.00	85.00	
HP08	3.00	85.00	
HP08	4.00	85.00	
HP08	5.00	85.00	
HP08	6.00	85.00	
HP08	7.00	86.00	
HP08	8.00	87.00	
HP08	9.00	[illegible]	
HP08	10.00	79.00	
HP08	11.00	79.00	
HP08	12.00	80.00	
HP08	13.00	[illegible]	
HP08	14.00	79.50	
HP08	15.00	79.00	
HP08	15.00	79.00	
HP08	17.00	77.00	
HP08	18.00	75.00	
HP08	19.00	53.00	
HP08	20.00	43.00	
HP08	21.00	40.00	
HP08	22.00	39.00	
HP08	23.00	40.00	
HP08	24.00	39.[illegible]	

B

DMSAG FILE 0221
ON-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD III

STD	DEPTH(M)	% TRANS	STN
MW01	0.0	43.00	1412
MW01	2.00	43.00	
MW01	4.00	44.00	
MW01	6.00	52.00	
MW01	8.00	55.00	
MW01	10.00	54.00	
MW01	12.00	55.00	
MW01	13.00	55.00	
MW02	0.0	48.00	
MW02	2.00	48.00	
MW02	4.00	50.00	
MW02	6.00	51.00	
MW02	8.00	51.00	
MW02	10.00	52.00	
MW02	12.00	53.00	
MW02	13.00	53.00	
MW03	0.0	51.00	
MW03	2.00	52.00	
MW03	4.00	52.00	
MW03	6.00	53.00	
MW03	8.00	53.00	
MW03	10.00	56.00	
MW03	12.00	56.00	
MW03	13.00	56.00	
MW04	0.0	52.00	
MW04	2.00	53.00	
MW04	4.00	53.00	
MW04	6.00	53.00	
MW04	8.00	53.00	
MW04	10.00	52.00	
MW04	12.00	53.00	
MW04	13.00	53.00	
MW05	0.0	50.00	
MW05	2.00	50.00	
MW05	4.00	49.00	
MW05	6.00	50.00	
MW05	8.00	49.00	
MW05	10.00	49.00	
MW05	12.00	50.00	
MW05	13.00	51.00	
MW19	0.0	61.00	1413
MW19	2.00	61.00	
MW19	4.00	61.50	
MW19	6.00	61.50	
MW19	8.00	61.50	
MW19	10.00	61.50	
MW19	12.00	65.00	
MW19	14.00	65.00	
MW19	16.00	63.00	
MW19	18.00	63.00	
MW19	20.00	63.00	
MW19	22.00	62.50	
MW19	24.00	52.50	
MW19	26.00	61.50	
MW19	28.00	62.00	
MW19	29.00	61.00	
MW19	30.00	61.00	
MW17	0.0	81.00	1414
MW17	2.00	83.00	
MW17	5.00	81.00	
MW17	9.00	81.00	
MW17	10.00	79.00	
MW17	12.00	79.00	
MW17	14.00	81.00	
MW17	16.00	80.00	
MW17	18.00	81.00	
MW17	20.00	82.00	
MW17	25.00	83.00	
MW17	30.00	84.00	
MW17	35.00	85.00	
MW17	40.00	86.00	
MW17	45.00	86.00	
MW17	50.00	87.00	
MW17	55.00	87.00	
MW17	60.00	89.00	
MW17	65.00	91.00	
MW17	70.00	91.00	
MW17	75.00	91.00	
MW17	80.00	91.00	
MW15	1.00	93.00	14[illegible]
MW15	2.00	95.00	
MW15	4.00	95.00	
MW15	6.00	95.00	
MW15	8.00	95.00	
MW15	10.00	95.00	
MW15	12.00	95.00	
MW15	14.00	95.00	
MW15	16.00	95.00	
MW15	18.00	[illegible]	
MW15	20.00	95.50	
MW15	25.00	[illegible]	
MW15	30.00	95.50	
MW15	35.00	95.00	
MW15	40.00	95.00	
MW15	45.00	95.00	
MW15	[illegible]	[illegible]	
MW15	55.00	[illegible]	
MW15	[illegible]	[illegible]	
MW15	[illegible]	[illegible]	
MW15	70.00	[illegible]	
MW15	75.00	[illegible]	
MW15	81.00	[illegible]	
MW15	[illegible]	[illegible]	
[illegible]	[illegible]	62.00	1[illegible]
[illegible]	2.00	[illegible]	
[illegible]	4.00	64.00	
[illegible]	[illegible]	[illegible]	
MW07	10.00	65.00	
MW07	12.00	65.00	
MW07	14.00	67.00	
MW07	15.00	69.00	
[illegible]	[illegible]	74.00	1[illegible]
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	87.00	
[illegible]	10.00	[illegible]	
[illegible]	12.00	[illegible]	
[illegible]	14.00	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	30.00	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	35.00	[illegible]	
[illegible]	40.00	85.00	
[illegible]	[illegible]	[illegible]	
[illegible]	43.00	[illegible]	
[illegible]	44.00	85.00	
[illegible]	[illegible]	[illegible]	
[illegible]	46.00	85.00	
MW11	0.0	[illegible]	1[illegible]
MW11	2.00	91.00	
MW11	4.00	[illegible]	
MW11	6.00	[illegible]	
MW11	[illegible]	[illegible]	
MW11	10.00	[illegible]	
MW11	12.00	[illegible]	
MW11	14.00	[illegible]	
MW11	[illegible]	89.00	
MW11	18.00	89.00	
MW11	20.00	90.00	
MW11	[illegible]	[illegible]	
MW11	[illegible]	[illegible]	
MW11	[illegible]	[illegible]	
MW11	[illegible]	[illegible]	
MW11	45.00	[illegible]	
MW11	50.00	[illegible]	
MW11	55.00	[illegible]	
MW11	60.00	[illegible]	
MW11	[illegible]	[illegible]	
MW11	70.00	90.00	
MW11	75.00	90.00	
MW11	[illegible]	90.00	
MW11	[illegible]	91.00	
MW13	1.00	92.00	1[illegible]
MW13	2.00	92.00	
MW13	4.00	93.00	

MW13	6.00	93.00	
MW13	8.00	93.50	
MW13	10.00	94.00	
MW13	12.00	94.00	
MW13	14.00	94.00	
MW13	16.00	94.50	
MW13	18.00	94.00	
MW13	20.00	94.50	
MW13	22.00	94.50	
MW13	25.00	93.50	
MW13	30.00	94.00	
MW13	35.00	94.00	
MW13	45.00	94.00	
MW13	40.00	94.00	
MW13	45.00	94.00	
MW13	50.00	94.00	
MW13	55.00	94.00	
MW13	60.00	94.50	
MW13	65.00	93.50	
MW13	70.00	93.50	
MW13	75.00	93.50	
MW13	80.00	93.50	
MW13	85.00	93.50	
MW21	0.0	93.00	1204
MW21	2.00	84.00	
MW21	4.00	84.50	
MW21	5.00	84.00	
MW21	6.00	84.50	
MW21	7.00	84.00	
MW21	8.00	84.00	
MW21	9.00	84.00	
MW21	10.00	84.00	
MW23	0.0	87.00	1205
MW23	2.00	86.00	
MW23	4.00	87.00	
MW23	6.00	87.00	
MW23	8.00	87.50	
MW23	10.00	87.50	
MW23	12.00	87.50	
MW23	14.00	87.50	
MW23	16.00	87.00	
MW25	0.0	74.00	1206
MW25	2.00	74.00	
MW25	4.00	74.00	
MW25	6.00	74.50	
MW25	8.00	74.50	
MW25	10.00	74.50	
MW25	12.00	74.00	
MW25	14.00	74.00	
MW25	16.00	73.50	
MW25	18.00	73.50	
MW25	20.00	71.50	
MW25	22.00	71.00	
MW25	24.00	70.00	
MW25	26.00	69.00	
MW27	0.0	77.00	1207
MW27	2.00	77.00	
MW27	4.00	79.00	
MW27	7.00	79.00	
MW27	8.00	78.00	
MW27	10.00	78.00	
MW27	12.00	77.00	
MW27	14.00	77.00	
MW27	16.00	77.00	
MW27	18.00	76.50	
MW27	20.00	76.00	
MW27	22.00	76.00	
MW27	23.00	72.00	
MW27	24.00	72.00	
MW27	25.00	70.00	
MW27	27.00	70.00	
MW27	29.00	69.00	
MW27	31.00	70.00	
MW27	33.00	65.00	
MW27	35.00	64.00	
MW27	37.00	65.00	
MW28	0.0	71.00	
MW28	2.00	72.00	
MW28	4.00	72.00	
MW28	6.00	71.00	
MW28	8.00	71.00	
MW28	10.00	71.00	
MW28	12.00	72.00	
MW28	14.00	71.00	
MW28	16.00	71.00	

[illegible]	18.40	67.00	
28	20.00	63.00	
28	22.00	58.00	
28	24.00	57.00	
[illegible]	26.00	55.00	
28	28.00	56.00	
28	29.00	56.00	
29	0.0	64.00	
29	2.00	64.00	
29	4.00	64.00	
29	6.00	64.00	
29	8.00	64.00	
29	10.00	64.00	
29	12.00	63.00	
29	14.00	62.00	
29	16.00	61.00	
29	18.00	60.00	
29	20.00	58.00	
29	22.00	52.00	
29	24.00	60.00	
29	26.00	60.00	
[illegible]	28.00	59.00	
[illegible]	29.00	60.00	
30	0.0	61.00	
30	2.00	63.00	
30	4.00	64.00	
30	5.00	63.00	
30	8.00	61.00	
30	10.00	57.00	
30	12.00	57.00	
30	14.00	55.00	
30	17.00	53.00	
30	18.00	56.00	
30	20.00	54.00	
30	22.00	54.00	
30	24.00	55.00	
30	26.00	54.00	
30	28.00	56.00	
30	29.00	51.00	
31	0.0	62.00	
31	2.00	62.00	
31	4.00	62.00	
31	6.00	62.00	
31	8.00	61.00	
31	10.00	60.00	
31	12.00	59.00	
31	14.00	59.00	
31	16.00	58.00	
31	18.00	59.00	
31	20.00	57.00	
31	22.00	57.00	
31	24.00	55.00	
31	26.00	52.00	
31	28.00	52.00	
31	30.00	52.00	
31	32.00	50.00	

33	0.0	82.00	1103
33	2.00	82.00	
33	4.00	83.00	
33	6.00	81.50	
33	8.00	81.00	
33	10.00	81.00	
33	12.00	81.00	
33	14.00	81.00	
33	16.00	82.00	
33	18.00	82.00	
33	20.00	82.00	
33	25.00	[illegible]	
33	30.00	[illegible]	
33	35.00	[illegible]	
33	40.00	[illegible]	
33	45.00	41.00	
33	50.00	43.00	
33	55.00	44.00	
33	60.00	[illegible]	
33	65.00	[illegible]	
33	70.00	[illegible]	
[illegible]	75.00	[illegible]	
[illegible]	80.00	[illegible]	
[illegible]	85.00	44.00	
[illegible]	90.00	44.00	
[illegible]	[illegible]	[illegible]	1102
[illegible]	2.00	[illegible]	
[illegible]	4.00	[illegible]	
[illegible]	6.[illegible]	[illegible]	
[illegible]	8.00	[illegible]	
34	10.00	47.50	
34	12.00	49.00	
34	14.00	48.50	
34	16.00	47.00	
34	18.00	47.00	
34	20.00	47.50	
34	22.00	47.00	
34	24.00	46.50	
34	26.00	45.00	
34	28.00	46.00	
34	30.00	45.00	
34	31.00	46.00	
34	32.00	47.00	
34	0.0	53.00	1101
34	2.00	55.00	
34	4.00	56.00	
34	6.00	55.00	
34	8.00	57.00	
34	10.00	57.00	
34	12.00	57.00	
34	14.00	57.00	
34	16.00	56.00	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD 111

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M*32~~	~~0.0~~	~~77.00~~	~~1207~~ 1103
M*32	2.00	77.00	
M*32	4.00	77.00	
M*32	6.00	77.00	
~~M*32~~	[illegible]	~~77.00~~	
M*32	10.00	77.50	
M*32	12.00	78.00	
M*32	14.00	78.00	
~~M*32~~	~~16.00~~	~~78.00~~	
M*32	18.00	69.00	
M*32	20.00	68.00	
M*32	22.00	6[illegible].00	
~~M*32~~	~~24.00~~	~~69.00~~	
M*32	26.00	71.00	
M*32	28.00	72.00	
M*32	30.00	75.00	
~~M*32~~	~~35.00~~	~~77.00~~	
M*32	40.00	82.00	
M*32	45.00	81.00	
M*32	50.00	81.00	
~~M*32~~	~~55.00~~	~~77.00~~	
M*32	60.00	62.00	
M*32	62.00	50.00	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M*37~~	~~0.0~~	~~85.00~~	~~1102~~ 1103
M*37	2.00	85.00	
M*37	4.00	85.00	
M*37	6.00	85.00	
~~M*37~~	~~8.00~~	~~87.00~~	
M*37	10.00	87.00	
M*37	12.00	87.00	
M*37	14.00	87.00	
~~M*37~~	~~16.00~~	~~87.00~~	
M*37	18.00	87.00	
M*37	20.00	87.00	
M*37	26.00	85.00	
~~M*37~~	~~30.00~~	~~87.00~~	
M*37	35.00	85.00	
M*37	40.00	77.00	
M*37	42.00	75.00	
~~M*37~~	~~44.00~~	~~73.00~~	
M*37	45.00	70.00	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M*35~~	~~0.0~~	~~54.00~~	~~1101~~ 1102
M*35	2.00	54.00	
M*35	4.00	54.50	
M*35	6.00	54.50	
~~M*35~~	~~8.00~~	[illegible]	
M*35	10.00	55.00	
M*35	12.00	54.00	
M*35	14.00	54.00	
~~M*35~~	~~16.00~~	~~53.00~~	
M*35	18.00	54.00	
M*35	20.00	53.50	
M*35	22.00	54.00	
~~M*35~~	~~24.00~~	~~53.50~~	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD III

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~MW15~~	~~0.0~~	~~83.00~~	~~1415~~ 1308
MW15	3.00	84.00	
MW15	5.00	84.00	
MW15	7.00	84.00	
~~MW15~~	~~10.00~~	~~83.50~~	
MW15	12.00	85.00	
MW15	14.00	85.00	
MW15	17.00	85.00	
~~MW15~~	~~20.00~~	~~85.50~~	
MW15	25.00	85.00	
MW15	30.00	88.00	
MW15	35.00	89.00	
~~MW15~~	~~40.00~~	~~91.00~~	
MW15	45.00	91.00	
MW15	50.00	90.50	
MW15	55.00	92.00	
~~MW15~~	~~60.00~~	~~92.50~~	
MW15	65.00	93.00	
MW15	70.00	92.00	
MW15	75.00	94.00	
~~MW15~~	~~80.00~~	~~95.00~~	
MW15	85.00	94.50	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~MW08~~	~~0.0~~	~~75.00~~	~~1308~~ 1309
MW08	2.00	77.00	
MW08	4.00	78.00	
MW08	6.00	78.00	
~~MW08~~	~~8.00~~	~~79.00~~	
MW08	10.00	80.00	
MW08	12.00	80.00	
MW08	14.00	80.00	
~~MW08~~	~~16.00~~	~~80.00~~	
MW08	18.00	81.00	
MW08	20.00	81.00	
MW08	22.00	81.00	
~~MW08~~	~~24.00~~	~~81.00~~	
MW08	26.00	81.00	
MW08	28.00	81.00	
MW08	30.00	81.00	
~~MW08~~	~~31.00~~	~~81 .~~	h------

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~MW10~~	~~0.0~~	~~82.00~~	~~1309~~ 1310
MW10	2.00	84.00	
MW10	4.00	85.00	
MW10	6.00	87.00	
~~MW10~~	~~8.00~~	~~89.00~~	
MW10	10.00	89.00	
MW10	12.00	90.00	
MW10	14.00	91.00	
~~MW20~~	~~0.0~~	~~81.00~~	
MW20	2.00	82.50	
MW20	4.00	82.50	
MW20	6.00	85.00	
~~MW20~~	~~8.00~~	~~[illegible]~~	
MW20	10.00	85.50	
MW20	12.00	85.50	
MW20	14.00	89.00	
~~MW20~~	~~16.00~~	~~88.50~~	
MW20	18.00	88.00	
MW20	20.00	87.00	
MW20	22.00	87.50	
~~MW20~~	~~25.00~~	~~87.00~~	
MW20	30.00	86.50	
MW20	35.00	85.00	
MW20	40.00	85.00	
~~MW20~~	~~45.00~~	~~77.00~~	
MW20	50.00	78.00	
MW20	55.00	79.00	
MW20	60.00	79.50	
~~MW20~~	~~70.00~~	~~79.50~~	
MW20	75.00	85.00	
MW20	80.00	85.50	
MW20	85.00	90.00	

DMSAG FILE 0221
OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD III

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#12~~	~~0.0~~	~~87.00~~	~~1310~~ 1311
M#12	2.00	87.00	
M#12	4.00	87.00	
M#12	6.00	87.00	
~~M#12~~	~~8.00~~	~~88.00~~	
M#12	10.00	88.00	
M#12	12.00	88.00	
M#12	14.00	88.00	
~~M#12~~	~~16.00~~	~~89.00~~	
M#12	18.00	89.00	
M#12	20.00	89.00	
M#12	25.00	89.00	
~~M#12~~	~~30.00~~	~~90.00~~	
M#12	35.00	90.00	
M#12	40.00	91.00	
M#12	45.00	91.00	
~~M#12~~	~~50.00~~	~~91.00~~	
M#12	55.00	91.00	
M#12	60.00	91.00	
M#12	65.00	91.00	
~~M#12~~	~~70.00~~	~~91.50~~	
M#12	75.00	92.00	
M#12	80.00	92.00	
M#12	85.00	92.00	

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OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD III

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#05~~	~~0.0~~	~~51.00~~	~~1412~~ 1413
M#05	2.00	54.00	
M#05	4.00	54.00	
M#05	6.00	54.00	
~~M#05~~	~~8.00~~	~~53.00~~	
M#05	10.00	51.00	
M#05	12.00	51.00	
M#05	14.00	49.00	
~~M#05~~	~~16.00~~	~~48.00~~	
M#05	18.00	44.00	
M#05	20.00	44.00	
M#05	22.00	35.00	
~~M#05~~	~~24.00~~	~~27.00~~	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#18~~	~~0.0~~	~~73.00~~	~~1414~~ 1415
M#18	2.00	73.00	
M#18	4.00	75.00	
M#18	6.00	75.00	
~~M#18~~	~~8.00~~	~~75.50~~	
M#18	10.00	75.00	
M#18	12.00	79.00	
M#18	14.00	81.50	
~~M#18~~	~~16.00~~	~~83.00~~	
M#18	19.00	84.00	
M#18	20.00	85.00	
M#18	22.00	87.50	
~~M#18~~	~~24.00~~	~~87.00~~	
M#18	26.00	87.00	
M#18	28.00	87.50	
M#18	30.00	85.00	
~~M#18~~	~~32.00~~	~~80.00~~	
M#18	34.00	77.00	
M#18	36.00	75.50	
M#18	37.00	75.00	

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OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD III

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#22~~	~~2.00~~	~~82.00~~	~~1204~~ 1265.--'-
M#22	4.00	82.00	
M#22	6.00	82.00	
M#22	8.00	81.00	
~~M#22~~	~~10 10.00~~	~~81.00~~	
M#22	12.00	81.00	
M#22	13.00	81.00	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#24~~	~~2.00~~	~~83.50~~	~~1205~~ 1206
M#24	4.00	82.00	
M#24	6.00	85.00	
M#24	8.00	84.00	
~~M#24~~	~~10.00~~	~~84.00~~	
M#24	12.00	85.00	
M#24	14.00	84.00	
M#24	16.00	83.00	
~~M#24~~	~~18.00~~	~~83.00~~	
M#24	20.00	83.00	
M#24	22.00	82.00	

SID	DEPTH(M)	% TRANS	BETWEEN STNS
~~M#25~~	~~0.0~~	~~74.00~~	~~1206~~ 1207
M#25	2.00	75.00	
M#25	4.00	74.50	
M#25	6.00	74.50	
~~M#25~~	~~8.00~~	~~74.00~~	
M#25	10.00	73.50	
M#25	12.00	73.00	
M#25	14.00	73.00	
~~M#25~~	~~16.00~~	~~73.00~~	
M#25	18.00	72.00	
M#25	20.00	69.00	
M#25	22.00	67.00	
~~M#25~~	~~24.00~~	~~66.00~~	
M#25	26.00	65.00	
M#25	28.00	65.00	
M#25	30.00	65.00	
~~M#25~~	~~32.00~~	~~65.00~~	
M#25	33.00	65.00	

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OFF-STATION TRANSMISSOMETRY DATA
SAMPLE PERIOD II

STD	DEPTH(M)	% TRANS	BETWEEN STNS
[illegible]	1.00	[illegible]	~~1103~~ 1102
HP16	2.00	92.00	
HP15	3.00	93.00	
HP16	4.00	94.00	
[illegible]	5.00	94.00	
HP16	6.00	96.00	
HP16	7.00	97.00	
HP16	8.00	97.00	
HP15	10.00	97.00	
HP15	11.00	97.00	
HP15	12.00	97.00	
HP15	13.00	97.00	
[illegible]	14.00	97.00	
HP16	15.00	97.00	
HP15	17.00	98.00	
HP15	19.00	98.00	
[illegible]	21.00	[illegible]	
HP16	23.00	97.00	
HP15	25.00	97.00	
HP16	27.00	97.00	
[illegible]	29.00	97.00	
HP15	31.00	97.00	
HP15	33.00	96.00	
HP15	35.00	95.00	
[illegible]	37.00	95.00	
HP15	39.00	95.00	
HP15	41.00	93.00	
HP15	43.00	92.00	
HP16	45.00	92.00	
HP15	47.00	91.00	

Appendix 2

% Trans	-alpha	% Trans	-alpha	% Trans	-alpha
100	0	59	.528	19	1.661
99	.010	58	.545	18	1.715
98	.020	57	.562	17	1.772
97	.030	56	.580	16	1.832
96	.041	55	.598	15	1.897
95	.050	54	.616	14	1.966
94	.062	53	.635	13	2.040
93	.073	52	.635	12	2.120
92	.083	51	.673	11	2.207
91	.094	50	.693	10	2.302
90	.105	49	.713	9	2.408
89	.116	48	.734	8	2.526
88	.128	47	.755	7	2.659
87	.139	46	.776	6	2.813
86	.150	45	.798	5	2.996
85	.162	44	.821	4	3.219
84	.174	43	.843	3	3.506
83	.186	42	.868	2	3.912
82	.198	41	.892	1	4.605
81	.211	40	.916		
80	.223	39	.942		
79	.236	38	.968		
78	.248	37	.994		
77	.261	36	1.022		
76	.274	35	1.050		
75	.288	34	1.078		
74	.301	33	1.109		
73	.315	32	1.139		
72	.328	31	1.171		
71	.342	30	1.204		
70	.357	29	1.238		
69	.371	28	1.272		
68	.386	27	1.309		
67	.400	26	1.347		
66	.415	25	1.386		
65	.431	24	1.427		
64	.446	23	1.470		
63	.462	22	1.514		
62	.478	21	1.561		
61	.494	20	1.609		
60	.511				